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Summary of Emissions Associated with Sources of Ethyl Chloride

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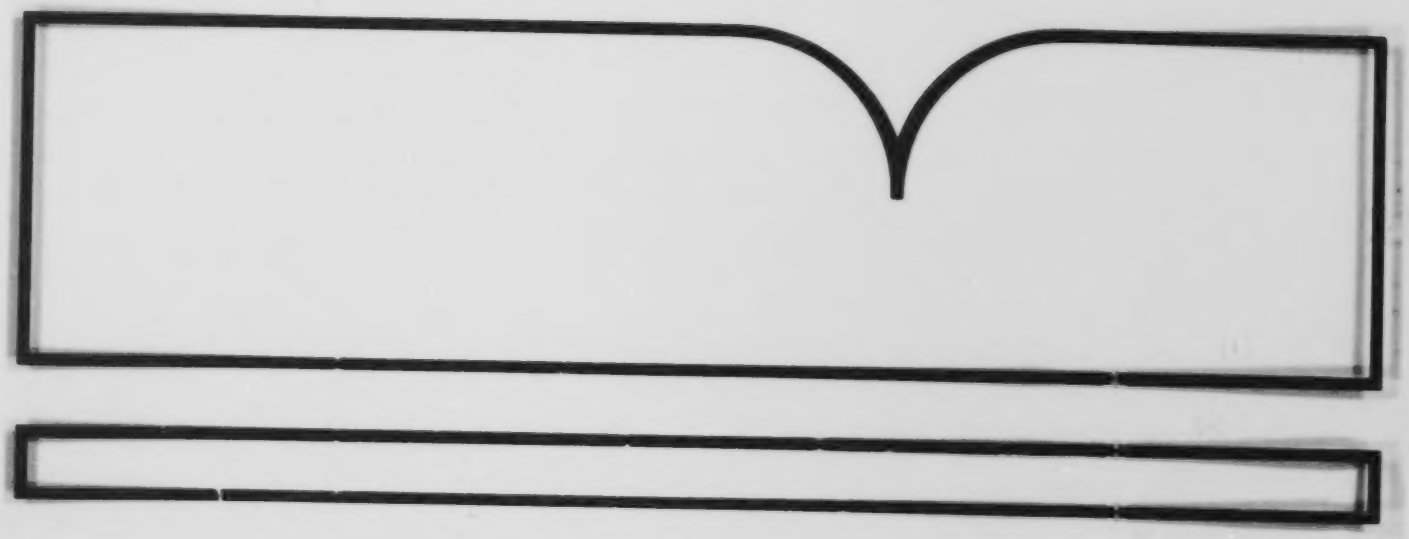

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The potential ambient health impact of ethyl chloride emissions has been investigated. This document contains information on the sources of ethyl chloride emissions, estimates current emission levels, summarizes production trends and ambient monitoring results. Results of this study provided inputs for the exposure and risk assessment of ethyl chloride.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field Group
Air Pollution Air Pollution Control Chloroethane Ethyl Chloride Foamed Plastics	Air Pollution	

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Emission Standards Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

June 1988

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1. ETHYL CHLORIDE CHARACTERISTICS

1.1 PHYSICAL PROPERTIES

Ethyl chloride, CH_3-CH_2-Cl, is a flammable gas under ambient conditions; however, at low temperatures or under pressure, it is a mobile, volatile liquid with a normal boiling point of 12.4°C.[1] It has a characteristic ethereal odor and is colorless.[2,3]

The solubility of water in ethyl chloride increases with temperature: 0.07 grams water in 100 grams ethyl chloride at 0°C, 0.36 grams water in 100 grams ethyl chloride at 50°C. At 0°C, the solubility of ethyl chloride in water is 0.447 grams per 100 millilitres water. At 20°C, solubililty in water increases to 0.574 grams ethyl chloride per 100 millilitres. Ethyl chloride also dissolves many organic substances such as fats, oils, resins, and waxes. It is also a solvent for sulphur and phosphorus as well as being miscible with methyl and ethyl alcohols, diethyl ether, ethyl acetate, methylene chloride, chloroform, carbon tetrachloride, and benzene. In alcohol at 20°C, there is a sharp increase in solubility to 48.3 grams ethyl chloride per 100 millilitres alcohol.[1]

Three binary azeotropes of ethyl chloride have been reported but the data are uncertain: second components are butane, ethyl nitrate, and 2-methylbutane.[3]

More physical properties are listed in Table 1.1-1. Ethyl chloride synonyms are listed in Appendix A.

Table 1.1-1 Ethyl Chloride Physical and Chemical Properties

Chemical Abstract Service (CAS) name:	Chloroethane
CAS registry number:	75-00-3
Molecular Weight	64.2
Melting Point, °C	-138.2
Boiling Point, 760 mm Hg, °C	12.4
Specific Gravity 20/4°C	0.8970
Critical Temperature, °C	186.6
Critical Pressure, atm	52
Flash Point, °C	
open	-43
closed	-50
Ignition Temperature, °C	519
Explosive Limit in Air, % by vol.	3.16-14
Explosive Limits in Oxygen, % by vol.	4.0-67.2

Vapor Pressure, mm Hg

-30°C	114	20°C	1011
-10°C	304	40°C	1938
0°C	464	60°C	3420
10°C	692	80°C	5632
12.2°C	760	100°C	8740

1.2 CHEMICAL PROPERTIES

Dry ethyl chloride may contact most common metals up to temperatures of 200°C in the absence of air without significant reaction its oxidation and hydrolysis are slow at ordinary temperatures. In the presence of steam and with various catalysts, ethyl chloride yields ethyl alcohol, acetaldehyde, and some ethylene; at 0°C, it forms regular crystals of a hydrate with water.[4]

Ethyl chloride may be dehydrochlorinated to ethylene using alcoholic potash, and forms diethyl ether as a reaction product during condensation with alcohol. If it is heated to 625°C and in contact with calcium oxide at 400-450°C, the primary product of decomposition is ethyl alcohol: Ethyl chloride exhibits a thermal stabililty similar to that of methylene chloride; it remains practically unchanged up to 400°C, at which point, decompositon to ethylene and hydrogen chloride occurs and increases within the 400-500°C range. Decomposition to the same products also occurs when ethyl chloride is heated to between 500-600°C and passed through a hot pumice packing, or when it comes into contact, at approximately 300°C, with the chlorides of nickel, lead, cobalt, and iron. In addition, some metals, inorganic salts and oxides (e.g. platinum, lithium chloride, calcium sulfate, alumina oxide, and silica) catalyze the cracking of ethyl chloride. Gaseous ethyl chloride reacts at 25°C with benzene, in the presence of a Friedel-Crafts catalyst, to yield ethylbenzene, three diethylbenzenes and other more complex compounds.[4]

Ethyl chloride burns with a smoky, green-colored flame, and produces hydrogen chloride, carbon dioxide, and water.[1]

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2. ETHYL CHLORIDE PRODUCTION

2.1 COMMERCIAL

The most important commercial process for the manufacture of ethyl chloride is hydrochlorination of ethylene. Hydrochlorination of ethylene is used by two of the four domestic producers. Hydrochlorination of ethanol has not been used for domestic ethyl chloride production since 1980. It was used by one domestic producer. A third process, chlorination of ethane, has not been used at any domestic production facility since 1974. The two producers who do not use hydrochlorination obtain ethyl chloride as a by-product from vinyl chloride or chlorofluorocarbon production. Ethyl chloride can also be obtained from the reaction of 1,2-dichloroethane and ethylene and from a subsequent direct reduction of the coproduct of this reaction, vinyl chloride. These processes probably only account for small amounts of ethyl chloride production. Table 2.1-1 lists ethyl chloride producers, capacities, and 1986 production estimates. [1,2]

2.1.1 Hydrochlorination of Ethylene

In 1970, over 80 percent of the ethyl chloride produced in this country was manufactured by the hydrochlorination of ethylene.[1]

$$\underset{\text{ethylene}}{CH_2{=}CH_2} + \underset{\text{hydrochloric acid}}{HCl} \xrightarrow[35\text{-}40^\circ C]{AlCl_3} \underset{\text{ethyl chloride}}{C_2H_5Cl}$$

In the U.S., the exothermic reaction is typically carried out at 35-40°C under 40 psig in the presence of a catalyst, such as aluminum chloride.[1] However, there are a variety of conditions under which this reaction may take place. At higher temperatures, the reaction rate is

Table 2.1-1 Ethyl Chloride Production: Producers, Locations, and Capacities

Company Name	Location	1987 Capacity[a] ($X10^6$ lbs)	1987 Capacity[a] ($X10^6$ kg)
Dow Chemical, USA	Freeport, TX	10	4.5
E.I. du Pont de Nemours & Co., Inc.	Deepwater, NJ	100	45
Ethyl Corp.	Pasadena, TX	160	73
PPG Industries, Inc.	Lake Charles, LA	125	57
TOTALS		460	

a. SRI International, Chemical Economics Handbook, Ethyl Chloride Data Summary. Menlo Park, California. February 1988. p.646.5030 B

accelerated but conversion drops off (occurring at 200-250°C) and polymerization products form, which ultimately destroy the catalyst.[3] Other variations on the reaction include contact with a thorium salt such as thorium oxychloride on silica gel at 175-400°C; use of 1,1,2-trichloroethane solvent for reaction at -5 to 55°C under 1-9 atms of pressure over an aluminum chloride catalyst, and high pressure reaction with a peroxygen catalyst.[4]

The hydrochlorination of ethylene to yield ethyl chloride is initiated when equimolar amounts of ethylene gas and anhydrous hydrogen chloride are mixed and subsequently passed into a reactor partially filled with ethylene dichloride, or a mixture of ethylene dichloride and ethyl chloride.[1,4] At reaction tempertures ranging between 35 and 45°C and at 40 psig, the exothermic hydrochlorination takes place in the presence of aluminum chloride. Vaporized products, including ethyl chloride, hydropolymer oil and miscellaneous chlorinated hydrocarbons, are sent to a separator where the lower boiling ethyl chloride is removed and further refined by fractionation. The separator bottoms, hydropolymer oil, is sold as a by-product, while the chlorinated hydrocarbon tails, removed as bottoms during fractionation, find use in chlorinated solvents manufacture. Ethylene, overheads of separation, is recycled and mixed with fresh ethylene as feed to the reactor. Similarly, ethylene dichloride, from fractionation, is recycled back to the reactor. Spent catalyst is continually withdrawn and replaced with fresh. The product, ethyl chloride, is generally sent to pressurized storage.[4] Refer to Figure 2.1-1 for a process schematic.

The hydropolymer oil is a low yield by-product as are the chlorinated hydrocarbon tails. The stream composition of the tails is broken down in Table 2.1-2. No production process wastes are sent directly to land disposal sites. They are, however, included with process wastes from chlorinated solvent production (co-production with ethyl chloride), and then sent to land disposal. Generally, the distillation residues, which make up the waste streams, contain 3 percent chloroethanes.[5] Yields of

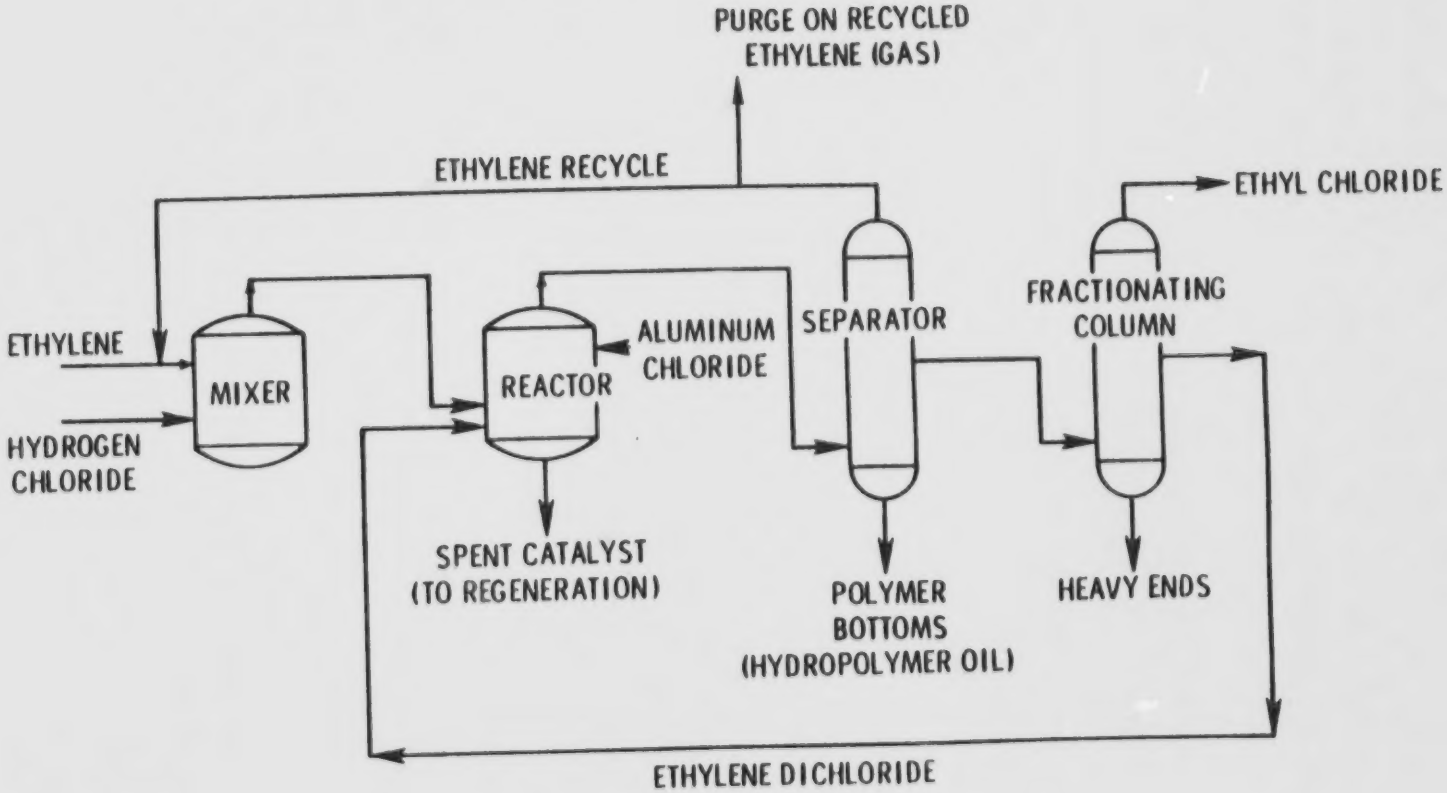

Figure 2.1-1 Process Schematic: Hydrochlorination of Ethylene

polymerization products may be reduced by the addition of ethylene dichloride to the reaction mixture, while overall yields of ethyl chloride are approximately 90-95 percent based on ethylene.[5]

Table 2.1-2. Chlorinated Hydrocarbon Tails (from fractionation)*

Component	% of stream
Etnyl chloride	3
Dichloroethanes	22
Trichloroethylene	32
Heavy Chlorinates	43

*Khan,ZS., TW Hughes, Monsanto Research Corp. Source Assessment: Chlorinated Hydrocarbons Manufacture, Office of Energy. Minerals, and Industry. EPA-600/2-79-019g Research Triangle Park, North Carolina. August 1979. p.27-28.

2.1.2. Hydrochlorination of Ethanol

Use of this process has probably ceased due to the increasing costs of alcohol relative to the less expensive and readily available petrochemical reactant. At one time, the reaction of ethanol and hydrochloric acid was the only established process for the production of etnyl chloride.[6]

$$\underset{\text{ethanol}}{C_2H_5OH} + \underset{\text{hydrochloric acid}}{HCl} \xrightarrow[\text{chloride}]{\text{zinc}} \underset{\text{ethyl chloride}}{C_2H_5Cl} + \underset{\text{water}}{H_2O}$$

Zinc chloride is usually the catalyst and the reaction temperature ranges from 110-140°C . Continuous distillation of the reaction mixture yields ethyl chloride and water.[6]

Hercules, Incorporated was the last company to use this manufacturing process in the U.S. A mixture of diethyl ether and ethanol is obtained was a by-product of their ethyl cellulose operation. Hydrochloric acid and fresh ethanol were added to this mixture for ethyl chloride production on site. The ethyl chloride, in turn, was used as a reactant in the manufacture of ethyl cellulose.[7] It is believed that they now purchase their ethyl chloride feedstock for ethyl cellulose production.

2.1.3 Chlorination of Ethane

Ethane may be chlorinated catalytically, electrolytically, thermally, or photochemically to produce ethyl chloride. Monochlorination is slower than subsequent chlorination: the rate at which ethyl chloride chlorinates is one-quarter the rate at which ethane chlorinates.[7] As a result, this process produces large amounts of polychlorinated compounds, and thus has lower yields of ethyl chloride. To reduce the level of by-products in the product mixture, excess hydrocarbons are added to the reaction mixture. The cost associated with this process currently precludes it from use in industry.[7]

2.1.4 Other Commercial Production Processes

Two of the production sites use facility - specific processes to obtain ethyl chloride. Information on these processes is scant. The indications are that ethyl chloride is produced at these facilities in small quantities on a non-continuous schedule, i.e on an as-needed basis. [2]

To obtain ethyl chloride at the Freeport, Texas facility, Dow Chemical probably uses the reaction between 1,2-dichloroethane and ethylene. The two reaction products are vinyl chloride and ethyl chloride. If larger quantities of ethyl chloride are desired, the vinyl chloride can be reduced to ethyl chloride.[2,6]

At their Deepwater, New Jersey facility, Du Pont can obtain ethyl chloride as a by-product from Freon® production.[2]

2.2 NONCOMMERCIAL

Processes which lend themselves to simplicity of process scheme, are economically attractive, and make use of readily available, inexpensive raw materials, are generally the processes of choice. They are adopted by industry and commercialized. However, there are other processes not employed by industry because they do not meet the above criteria. These non-commercialized processes for the manufacture of ethyl chloride include:

1. A catalyzed, two-step reaction of ethylene, sulfuric acid, and sodium chloride to produce ethyl chloride and sodium sulfate. The intermediate product is diethyl sulfate $(C_2H_5O)_2\ SO_2$.[6]

2. The catalytic reaction of diethyl ether with hydrochloric acid.[12]

Ethyl chloride is also produced unintentionally in other industrial processes. For example, ethyl chloride is a by-product of ethylene dichloride (EDC) manufacture. As noted in the commercial production section of this report, ethyl chloride can be obtained as a by-product from Freon®, or chloroflurocarbon, manufacture. This indicates that it might be a by-product of Freon® manufacture whether or not it is desired. Ethyl chloride could be a by-product in the chlorination of other hydrocarbons.

From these possibilities, emission estimates were developed only for EDC production. An unusually large amount of information was available for this process due to recent data collection and estimates for EDC emissions. Data were not available for evaluation of ethyl chloride emissions and by-production from other possible point sources.

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3. ETHYL CHLORIDE USES

Ethyl chloride has a low production volume (163.5 million lbs, 1986).[1] It is used primarily as a chemical intermediate for the manufacture of other chemical compounds. It has few large-scale industrial uses. In 1981, 82 percent of domestic consumption was attributed to the production of tetraethyl lead (TEL), a gasoline antiknock additive. By 1986, manufacture of this compound remained the largest single use of ethyl chloride, but had dropped to 68 percent of ethyl chloride consumption. Ethyl chloride is a reactant in the production of ethylcellulose (EC) and ethylhydroxyethylcellulose (EHEC). These cellulosic ethers comprise the second largest consumption category for domestic ethyl chloride consumption. Other uses of ethyl chloride include use as a foam blowing agent for polystyrene foam a local anesthetic, as a promoting agent in ethylation, and in the production of alkyl catalysts and aerosols. It has also been used as a solvent and refrigerant, but believed no longer to be in this service.[1]

3.1 TETRAETHYL LEAD

The demand for TEL as an antiknock agent has declined due to the regulations imposed by the U.S. Environmental Protection Agency. As of January 1, 1986, the grams of lead allowed per gallon of leaded gasoline (gplg) were limited to 0.1 gplg. The previous phasedown level was 1.1 gplg. The Agency has projected the 1990 demand for leaded gasoline to be 27.6 billion gallons. This would be a reduction of 31 percent from the 1985 level of 40.2 billion gallons. Under the new standard (40 CFR, Part 80), lead usage in 1990 will be down to 2.8 billion grams from 32.2 billion grams for 1985.[2] Table 3.1-1 gives estimates for lead and leaded gasoline usage.

Table 3.1-1 Probable Lead Usage under Promulgated Regulations*

Year	Total Gasoline (10^9)	Leaded Demand (10^9) Current projection	Lead usage expected** (10^9 grams)
1985	100.6	40.2	32.2
1986	100.3	37.5	3.8
1988	99.6	32.4	3.2
1990	99.0	27.6	2.8

*Federal Register, vol 50, no.45, March 7, 1985(40CFR Part 80)
**Based upon 0.10 gply regulation.

Of the four domestic producers operating TEL facilities in 1973, three remained open in 1985. Since 1986, only one domestic producer has operated a TEL production facility. As the demand for leaded antiknock additives continues to drop, reliance upon the existing overseas market increases. However, regulations are being imposed in many foreign countries as to the permissible levels of lead in their motor vehicle gasoline. One exception to this is Mexico. Mexico consumed an estimated 28 million lbs of ethyl chloride (92 percent of U.S. exports) for TEL production in 1986.[1] The location and capacity of the remaining TEL manfacturing facility is reported in Table 3.1-2. The production levels and estimated consumption (1970-1982) are provided in Appendix B.[1,4,5]

Table 3.1-2 Tetraethyl Lead Capacity*

Company	Location	Year	Capacity (10^6 lb/yr)	Capacity (Gg/yr)
E.I. du Pont de Nemours & Co., Inc.	Deepwater, New Jersey	1985	143	65
		1986	100	45

b. SRI International, Chemical Economics Handbook, Gasoline Octain Improvers, CEH Marketing Research Report, Menlo Park, CA. September 1986.p. 543.7051R

In the past, TEL was the preferred octane improver for gasoline blends. An octane improver is added to liquid fuels to inhibit knocking in internal combustion engines. The relative antiknock properties of liquid motor fuels are compared by using octane numbers. The octane number of a fuel is the volume percent of isooctane in a reference fuel which matches the knocking properties of the tested fuel. The reference fuel is composed of isooctane and normal heptane. Octane numbers of U.S. gasolines are generally in the range of 87 to 92.[3]

Octane improving agents which have replaced TEL include: methyl tertiary-butyl ether (MTBE), ethanol, methanol, and tertiary-butyl alcohol (TBA). Other possible octane improvers are aliphatic alcohols (e.g. propanols) and aliphatic ethers (e.g., methyl t-amyl ether (TAME)).[3]

TEL has been manufactured by electrolysis of a Grignard reagent and by alkylation of a lead-sodium alloy. The lead-sodium alkylation is the only process currently in use. The alkylation process was originally a batch operation. In this process sodium-lead alloy reacts with ethyl chloride and a catalyst (usually acetone) to form tetraethyl lead (TEL).

$4PbNa$	+	$4C_2H_5Cl$	->	$Pb(C_2H_5)_4$	+	$3Pb$	+	$4NaCl$
sodium-lead alloy		ethyl Chloride		TEL		lead		sodium chloride

The sodium-lead alloy is in a powdered or crushed form. It is composed of 90 percent lead and 10 percent sodium. All operations are nitrogen blanketed.

Ethyl chloride, in excess of that theoretically required, is added to the alloy in an autoclave. The reaction is exothermic. To help maintain the proper temperature, ethyl chloride is refluxed. After the reaction is completed, unreacted ethyl chloride is vented and TEL is recovered from the residual solids. The TEL is sent to a blending unit for the antiknock mixture. The theoretical yield is 1.25 pounds of TEL per pound of ethyl chloride consumed. Lead antiknock motor mixes are standardized and contain 0.394 lb of lead per lb of mixture. This corresponds to 61.48 wt. percent TEL. [6,7,3]

The continuous alkylation process was developed at du Pont in 1953 at its Deepwater, New Jersey, facility. The reaction is the same as that of the batch process, however, this production unit is designed for continuous processing. The reaction proceeds under pressures of about 230-300 psi, and at temperatures between 110-150°C. The sodium-lead alloy is fed continuously to an agitated cascade reactor vessel with excess ethyl chloride and a catalyst. A reflux of ethyl chloride provides cooling. The reactants are allowed several minutes of residence time. The contents are then moved to a stripper for steam/water injection to facilitate the separation of the TEL from the reactor slurry. Anti-agglomerating agents are added to the product to prevent the metallic lead from forming balls or rings. TEL, ethyl chloride, and water vapors are retrieved as overheads during separation. The TEL and ethyl chloride are then purified and the ethyl chloride is recycled. The reaction bottoms are washed to remove sodium chloride (NaCl) and to recover the lead. A process block diagram is provided in Figure 3.1-1. Although this process is more complex than the batch process it is more efficient due to the higher throughput and smaller work crew.[7]

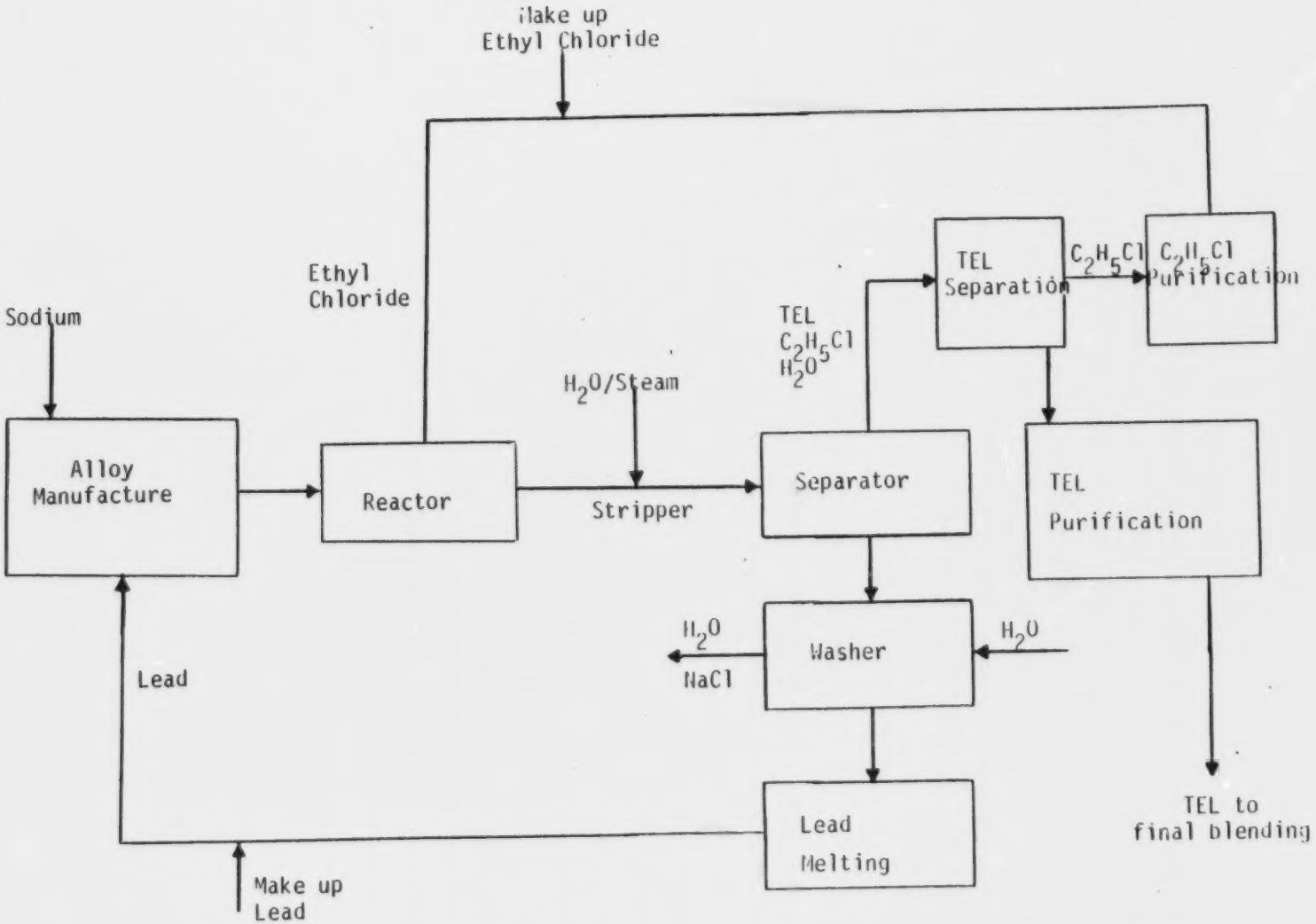

Figure 3.1-1 Simplified Block Diagram: Tetraethyl Lead from Sodium-Lead Alloy

3.2 CELLULOSE ETHERS

Ethylcellulose (EC) and ethylhydroxyethylcellulose (EHEC) are thermoplastic cellulose ethers. Ethylcellulose plastics may be molded or machined. They are able to retain flexibility at temperatures ranging from -40 to +100°C. They are among the toughest of thermoplastic materials, offering resin and plasticizer compatability, stability to heat, low flammability, and electrical resistance.[8,9,10] Although these ethers are generally water insoluble, they are soluble in many organic solvents.[12] EHEC offers better solubility in aliphatic-rich solvents than does ethylcellulose.

In 1965, domestic consumption of EC and EHEC reached 8 million pounds. By 1973, this consumption peaked at 9 million. In 1974, consumption dropped to 7 million pounds, where it remained until 1976.[11] In that same year approximately 11 million pounds of EC and EHEC were produced domestically. The remaining 4 million pounds were exported.

In 1983, U.S. consumption of cellulose ethers was 143 million pounds. This market is primarily composed of sodium carboxymethyl cellulose (CMC), 59 million lbs; and hydroxyethyl cellulose (HEC), 41.5 million lbs.[12,13] In that year, 8 million lbs of EC and EHEC were consumed domestically.

Domestic demand of cellulose ethers is expected to grow by 2.5 percent annually between 1983 and 1988. During this time period no growth is expected for EC and EHEC.[12]

3.2.1 Ethyl Cellulose (EC)

Two U.S. facilities manufacture EC, and they are listed in Table 3.2-1. Hercules at Hopewell, VA, is the only domestic producer of ethylhydroxy ethylcellulose (EHEC). It is estimated that the total capacity for production is 15 million pounds.[1] Cotton and wood pulp have both been used as the cellulose source to prepare EC.

Main Reaction: $R_{cell}OH + NaOH \Leftrightarrow R_{cell}OH.NaOH$

$$R_{cell}OH.NaOH + C_2H_5Cl \rightarrow R_{cell}OC_2H_5 + NaCl + H_2O$$

Side Reactions: $C_2H_5Cl + NaOH \rightarrow C_2H_5OH + NaCl$

$$C_2H_5OH + C_2H_5Cl + NaOH \rightarrow C_2H_5OC_2H_5 + NaCl + H_2O$$

There are four main steps to EC manufacture: alkali cellulose preparation, reaction with cellulose, by-product recovery, and washing and drying. Generally, alkalai cellulose is made first with a saturated sodium hydroxide (NaOH) solution. It is then added, along with the ethyl chloride, to an agitated, nickel-lined, pressurized vessel where it is ethylated between 90 and 150° C for 6-12 hours. The process is carefully controlled so as not to cause degradation of the cellulose chain or destruction of the ethyl chloride. A dilutent (solvent to the process) may be added to decrease the rate of reaction.

Table 3.2-1 Ethylcellulose Facilities *

Company	Location	1983 Capacity* 10^6 lb/yr	1983 Production 10^6 lb/yr	1983 Domestic Consumption of EC & EHEC 10^6 lb/yr
Dow Chemical Co.	Midland, MI	unavailable	unavailable	----
Hercules, Inc.	Hopewell, VA	7	unavailable	----
TOTAL		unavailable	11	8

*SRI International, Chemical Economics Handbook, Cellulose Ethers, Menlo Park, CA. December 1984, p.581.5022D,I,X.

By-products, such as diethyl ether, ethanol, unreacted ethyl chloride, and solvent, may be flashed from the crude ethyl cellulose in the reactor or in a separate step. They may then be recovered by fractionation. Spent NaOH is recovered while ethyl alcohol and ether, by-products of the reaction, may be converted to ethyl chloride by heating with HCl in the presence of a zinc-chloride catalyst. [8,10] The ethyl chloride product, a granular precipitate, is purified by washing in stainless steel equipment.

Finally, the product is dried and packaged. The above process is believed to be in use by Hercules Co., at their Hopewell, Virginia, facility. The ethyl chloride produced by the catalytic hydrochlorination of alcohol immediately finds use as a reactant in their ethylcellulose operation.

The degree of ethoxyl substitution varies with the concentration of NaOH. It may also be controlled by the input of ethyl chloride the reaction temperature, and the length of time the components remain in the reactor.[8,10]

The operation is normally carried out as a batch process with excess NaOH and ethyl chloride as the limiting reagent. However, as a semicontinuous process, excess ethyl chloride would be used with NaOH as the limiting reagent. Over one half of the ethyl chloride might be consumed in side reactions.[10] A German batch process using 628 kgs of a 50% caustic soda solution, 45 kgs of chemical wood pulp, and 20 kg of ethyl chloride, yielded 56 kgs of product with an ethoxyl content of 47-48 percent, or 0.25 kg ethylcellulose per kg ethyl chloride.[8]

Ethylcellulose is tough and impact resistant. It is used as a protective lacquer (e.g. on bowling pins) and in specialty coatings. However, the high costs associated with EC lacquers are expected to deter their growth as surface coatings, which traditionally has been the largest market. It can be used as an additive in the feed and drinking water of market animals.[13] In addition, it is used in hot-melt or solvent adhesives, printing inks, films, foils, and plastic products.[8,11]

3.2.2 Ethylhydroxyethylcellulose (EHEC)

Ethylhydroxyethylcellulose (EHEC) is similar to EC except that it is soluble in a wider range of solvents. It is manufactured in a water-soluble grade by a company in Sweden. These water-soluble cellulose ethers have been manufactured in Sweden under the trade names of Modocell E and F, since 1945.[8]

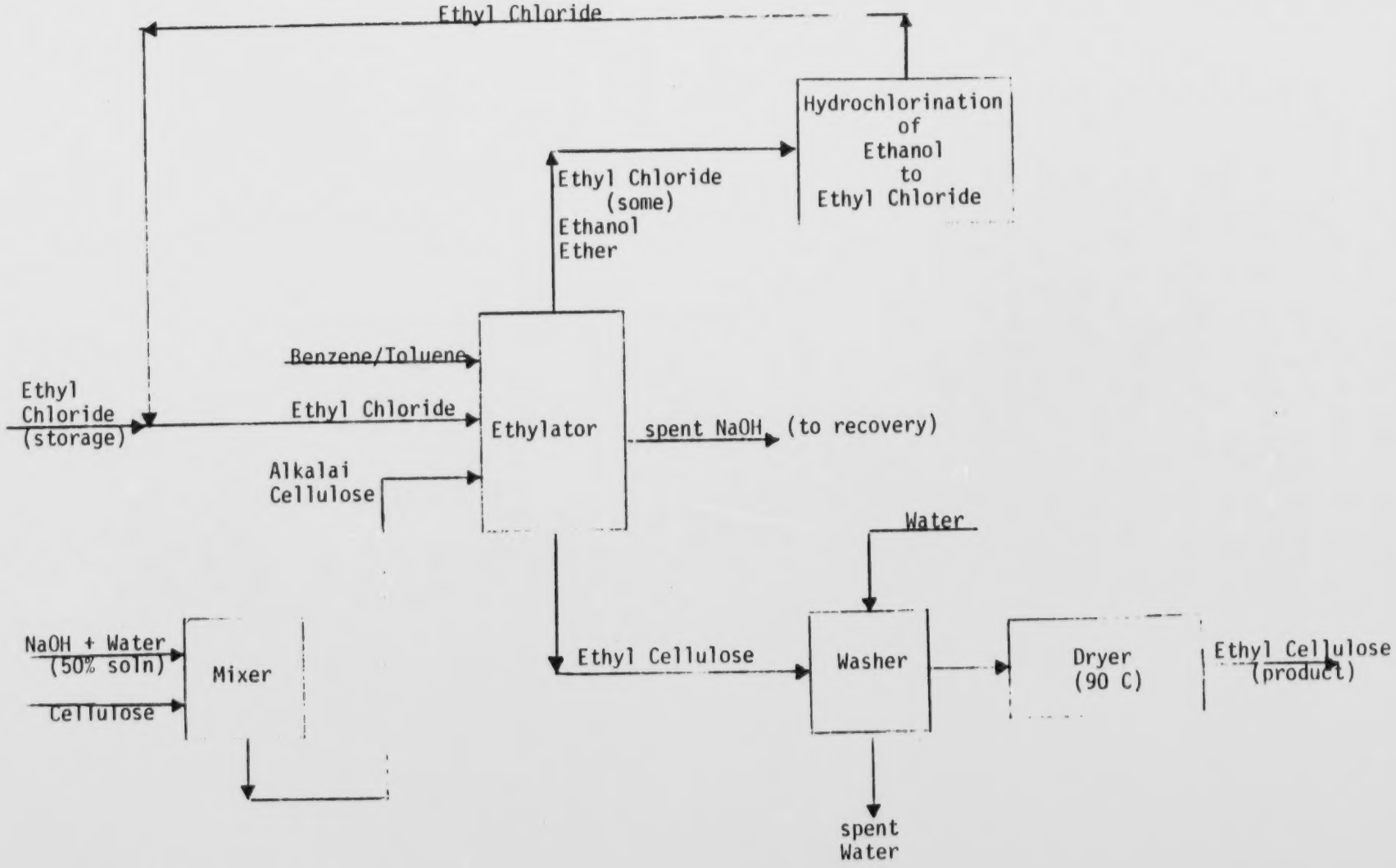

Figure 3.2-1 Block Diagram: Ethyl Cellulose

The manufacture of EHEC involves the treatment of alkalai cellulose with ethyl chloride and ethylene oxide, and is produced by the same process as the previously mentioned ethylation procedures. They find application as additives in silkscreen and gravure inks. They are also used as thickeners in emulsion paints and paint removers, as binders, and also as pastes (e.g. wallpaper).[8]

3.3 FOAMED PLASTICS

Foamed plastics, also referred to as cellular plastics or cellular polymers, have found commercial application since the 1940's. A foamed plastic is a plastic with an apparent density substantially decreased by the presence of numerous cells throughout its mass. The term most often refers to a two-phase gas-solid system where the continuous solid phase is a synthetic plastic or rubber and the gas phase is distributed in voids or pockets referred to as cells. If the cells are discrete and independent of each other, the material is termed "closed cell." If the cells are interconnected such that gas may travel from one to another, it is termed "open cell." Rigid foams are closed-cell plastics; flexible foams are open-cell plastics. Common foamed plastics include polyurethane, cellular rubber, latex foam rubber, polyvinyl chloride, polystyrene and phenolic resin. Phenolics, polystyrene and polyurethanes are used mainly for rigid foams while vinyls and linear polyurethanes are used in flexible foams.[14,15]

Foamed plastics may be manufactured by a variety of methods and take forms such as slabs, blocks, boards, beads, sheet, film, molded shapes and extruded insulation. The most distinctive step is the expansion of the fluid polymer phase to the low-density cellular state. This step is known as foaming or expanding.[14,15]

Most thermosetting and thermo-plastic polymers can be foamed (expanded) by the addition of blowing agents.[15] The selection of these agents is critical to the formation of the cellular structure and in imparting the desired and necessary properties to the final product.[16] The agents are mixed with the polymer. They react or volatilize to form a gaseous phase. The aggregation of these gaseous molecules creates the cellular structure.[17]

Blowing agents can be classified into two groups: physical and chemical. Physical blowing agents are gases or low boiling liquids that do not react chemically in the foam blowing process. Examples of these physical agents are nitrogen, air, methylene chloride, and ethyl chloride. These agents are combined with the polymer and released, or volatilized, by process heat or by heat of polymerization.

Chemical agents generally are finely powdered and easily mixed with resin for processing. Examples of chemical blowing agents are: hydrazine derivatives, sodium bicarbonate, isocyanates, and other organic and inorganic chemicals. These compounds decompose to gases, such as nitrogen, carbon dioxide, carbon monoxide, ammonia, and others. The released gases then form the cellular structure. Chemical blowing agents can be used for foam densities of 2b lb/cu ft. or higher and, when accompanied by a physical blowing agent, they can also be used as nucleating agents. Nucleating agents, such as talc or finely divided fillers, facilitate bubble formation, or clustering, of the gas molecules.[17]

Dow Chemical, U.S.A., uses ethyl chloride and methylene chloride and CFC-12 as blowing agents in the manufacture of Styrofoam.® Styrofoam® is the brand name of a closed cell, extended polystyrene foam product. Dow uses ethyl chloride because of its dimensional stability, moisture resistance, compressive strength, ease of handling, and other good physical characteristics. Some blowing agent selection criteria are given below:[16]

1. Any replacement product should have high solubility in polystyrene at high temperature for acceptable processing.
2. Low solubility in polystyrene at low temperature for high compressive strength and dimensional stability.
3. Relatively high diffusivity of primary blowing agent through the polymer for dimensional stability and low diffusivity of secondary blowing agent for high insulation value.
4. Capability of producing large cells in order to produce whole product mix with cell size ranging from 0.1 mm to 2.4 mm.
5. Sufficient vapor pressure (or blowing power) to produce thick products.
6. High latent heat of vaporization for dimensional stability.
7. Low reactivity with formulations.
8. Low toxicity (acute and chronic).
9. Low flammability in the process and the product.
10. Stratospheric ozone acceptability.
11. Cost.

N-pentane is a blowing agent for expandable polystyrene beads.[19] The chloroflurocarbon, CFC-12, is also a blowing agent for extruded polystyrene foam. These products differ in some ways from the Styrofoam® products but they are considered competitive in some markets.[16]

Due to the availability of specific information on the use of ethyl chloride as a blowing agent in the Styrofoam® extrusion process, the focus in this section will be placed on the manufacture of this brand of extruded polystyrene foam. Currently, Styrofoam® is the only polystyrene foam known to use ethyl chloride as a blowing agent.

There are two major types of expanded polystyrene products: extruded polystyrene foam and expandable polystyrene beads. The expandable beads are manufactured by a variety of processes. The beads are used as loose fill or molded into cups, boards, and other end products.

Extruded polystyrene foam, such as Styrofoam®, is used in construction, packaging, and other end uses. Polystyrene foam is usually manufactured as boards which are then cut in desired sizes. The board is used as insulating material in buildings and in cold storage compartments. Polystyrene foam is also used in insulation board for roofing and as laminates for sheatning products.[19]

The extrusion of styrene polymers is one of the most convenient and least expensive methods for fabricating sheet, pipes and film. The function of the extruder is to plasticate the resin to the proper viscosity for absorption of the blowing agent, to mix all components, and to cool the mixture to a temperature that will provide optimum properties for foam applications. The type and amount of blowing agent, the extrusion process conditions, and the cooling and stretching techniques affect density and other foam properties. Extruded polystyrene foam planks and boards, with densities near 29 kg/m^3, are often used for low temperature thermal insulation, buoyancy, floral displays, novelty items, packaging and construction. Extruded polystyrene sheet 1-7 mm thick, with densities in the range of 64-160 kg/m^3, are often used in packaging.[17,18]

Three extrusion systems are used to extrude thermoplastic foam: single-screw, twin-screw, tandem. The single-screw extruders have been used more frequently with medium to high density foam applications (320-800 kg/m^3) where blowing agents are used. These systems operate under very high pressures, which are necessary to assure formation of fine, discrete cells. They have been most widely used in extruding foam profiles for use as wood molding and trim replacements, although they are becoming more popular for the production of high density foam sheet. The twin-screw systems are most suited to medium density foam applications. Lower melt temperatures in the cooling zone are possible with this system due to a lower input of mechanical work for mixing the resin and the blowing agent. They operate essentially as positive displacement pumps and only offer one screw speed for melting, mixing and cooling.

The tandem or two-extruder system is the most popular extrusion system in the United States. It offers direct injection of physical blowing agents and is especially well suited to extrusion of low to medium density foams. Their principle application is in extruded foam sheet in gages of 0.25 to 3.8 mm wide or less. The resin and nucleating agent are fed into the first stage of the primary extruder and melted. A liquified blowing agent is metered through the barrel into the second stage of the primary extruder, where it is thoroughly mixed with resin and nucleating agent. This mixture is pumped into the secondary extruder where it is gently stirred, cooled, and advanced to the die. As the gaseous polymer melt exits the die, the pressure falls below the vaporization pressure of the blowing agent. The vaporization of the blowing agent forms the foam cells.[17,18]

3.4 ANESTHETICS

Ethyl chloride is currently marketed in the U.S. as a topical anesthetic. It is available in 100 gram unbreakable metal tubes with a fingertip-control, adjustable valve. It is also available in a light resistant, 4-oz amber glass bottle with a spring cap. The cap is available in four calibrations: fine (under 0.005-inch spray width), medium (0.005- to 0.008-inch spray width), coarse (0.008- to 0.011-inch spray width), and in a mist spray. The ethyl chloride used in this service is approximately 99 percent pure, but may be diluted for bottling. Further information regarding this use is available from:[20]

GeBauer Chemical Company
Cleveland, Ohio 44104
(800) 321-9348

3.5 ETHYLBENZENE

It has been reported that ethyl chloride is used as an ethylating agent in the production of dyestuffs and specialty chemicals. One such use is in the Freidel-Crafts alkylation of benzene to ethylbenzene. Ethyl chloride or hydrogen chloride may be used as an initiator in this liquid phase reaction.[5,21,22]

Although this use has been documented, more specific information on the extent of its use has not been found in the literature.

3.6 OTHER USES

Some other very limited uses of ethyl chloride include use as a feedstock in the production of 1,1,1-trichloroethane, as a solvent and refrigerant, and as an aerosol propellant. Ethyl chloride has been used for a number of years as the working fluid at an electric power plant on the Island of Ischia in the Bay of Naples. A temperature difference of over 30°C exists between the local thermal streams and the surrounding sea water; ethyl chloride is used to "extract" power from the geothermally heated water.[23] Ethyl chloride was included in the emissions inventory for a Rhone Poulenc ethyl vanillin facility in Freeport, Texas.[24] However, more extensive or descriptive information on the process was not available.

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4. INDUSTRIAL PERSPECTIVE

4.1 HISTORICAL TRENDS

Between 1965 and 1975, ethyl chloride production increased at an average growth rate of 0.5 percent per year. Between 1975 and 1979, this rate averaged 1.61 percent: 16.3 percent from 1975-76, -19.3 percent from 1976-78, 7.82 percent from 1978-79. Refer to Table 4.1-1 for yearly production figures. The economic history of ethyl chloride has been

Table 4.1-1 Yearly Ethyl Chloride Production*

Year	Production 10^6 lbs	Year	Production 10^6 lbs
1955	541.6	1970	678.0
1956	645.5	1971	620.3
1957	604.4	1972	575.5
1958	535.7	1973	660.1
1959	550.8	1974	662.5
1960	545.4	1975	575.2
1961	496.8	1976	669.2
1962	536.8	1977	612.5
1963	591.8	1978	539.8
1964	666.1	1979	582.0
1965	685.8	1980	396.4
1966	677.0	1981	324.3
1967	618.2	1982	339.2
1968	573.1	1983	281.7
1969	678.8	1984	290.2
		1985	170.5
		1986**	156.9
		1987**	164.4 (projected)

*SRI International, Chemical Economics Handbook. Menlo Park, CA. February 1988. p.646.5030 C

**SRI International, Chemical Economics Handbook, Manual of Current Indicators. April 1988. p.646.5030 B

4.1.1 Imports

Over the past ten years, ethyl chloride imports have been significant only in 1980, 1981, and 1982. During those years, imported quantities were 3, 11, and 5 million pounds, respectively. Before 1980 and since 1983, ethyl chloride has been imported either in negligible quantities or not at all. In 1986, the last year for which import data are available, no ethyl chloride was imported into the United States.[6]

4.1.2 Exports

Domestically produced ethyl chloride is exported in significant quantities. Mexico has been a major importer of domestic ethyl chloride. Its use in these cases is primarily in tetraethyl lead manufacture. In 1986, of the 31 million lbs of ethyl chloride exported, 92 percent was sent to Mexico for TEL production.[5]

4.2 OUTLOOK

Only four ethyl chloride production companies are currently operating. Hercules closed its Hopewell, Virginia facility in 1980.[5]Although the manufacture of TEL has been the primary end use of ethyl chloride, federal regulations(40 CFR Part 80) on the allowable lead content in gasoline continue to decrease the demand for this antiknock additive.

The new regulation has reduced, by approximately 90 percent, the previously existing regulation of 1.1 grams of lead per leaded gallon (gplg) to 0.10 gplg. As a result, manufacturers must rely

upon an overseas market in order to keep TEL production active. However, members of the European Economic Community (EEC) were required, as of January 1, 1981, to limit the lead content to 0.4 and 0.15 grams per litre for premium and regular grade gasoline, respectively.[6] Some have voluntarily reduced to levels below those required. In 1982, Japanese lead levels in gasoline were 0.3 and 0.0 millilitres per litre premium and regular, respectively. Their TEL consumption peaked in 1969 and has declined 24 percent annually to a 1981 level of 600 tons (100 percent basis).[7] According to this 1982 source, the Japanese were expected to halt consumption altogether by 1986.

Domestic ethyl chloride production and consumption continue to decline. Leaded gasoline currently comprises 40 percent of the gasoline market and is expected to continue decreasing.[5] If TEL foreign markets expand, this may offset the decline in domestic demand and the parallel decline in ethyl chloride production.[3] The other minor end uses of ethyl chloride, manufacture of cellulose ethers and some pharmaceutical application, have not seen a significant increase in activity in the recent past, and no significant increases in demand are anticipated in the near future.[2]

4.3 REFERENCES

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5. EMISSIONS

Emissions from identified sources are listed below according to process.

5.1 INDUSTRIAL

5.1.1 Production

5.1.1.1 Hydrochlorination of Ethylene. Emission rates were estimated for each production site using current data on operations at the Ethyl Corporation Pasadena, Texas facility as a basis for calculation of emission factors.[1] These rates may be found in Table 5.1-1. These estimates, in addition to emission parameters, and other site specific information have been included as input to the Human Exposure Model (HEM), and are provided in Appendix H. Calculations on ethyl chloride emissions from production (process, equipment leaks, transportation, storage) are provided in Appendix C.

5.1.1.2 Other Production Processes

Although only two of the ethyl chloride production facilities use the hydrochlorination process, emission data for the other processes were not available. The emission estimates for all processes were based upon the data for ethylene hydrochlorination[2]

Table 5.1-1 Estimated Emissions from Ethyl Chloride Production

Company, Location	1987 Capacity (Gg/yr)	Emission Type	Estimated Emissions[a,b] (kg/yr)
Dow Chemical			
Freeport, TX	4.54	process	2,180
		process	2,180
		equipment leaks	29,600
DuPont	45.4	proce	21,800
Deepwater, NJ		process	21,800
		equipment leaks	29,600
Ethyl Chloride			
Pasadena, TX	72.6	process	34,800
		process	34,800
		equipment leaks	29,600
PPG Industries			
Lake Charles, LA	56.7	process	27,200
		process	27,200
		equipment leaks	29,600
TOTAL			210 Mg/yr

a. Process emissions were assumed to come equally from two vents. Emission factor per process vent = 480 kg/Gg capacity.

b. Equipment leaks based on Model A plant, 100 percent ethyl chloride service. See appendicies for calculations and assumptions.

5.1.2.1. Tetraethyl Lead (TEL)

The process emissions for the only remaining TEL production facility were obtained from the permitting records of the State of New Jersey.[4] These emissions were given for ethyl chloride emissions from process units at Du Pont's facility at Deepwater/ Pennsville, New Jersey. The appendicies D and H list the complete data (including stream characteristics) which were necessary for dispersion modeling.

The available data did not contain emissions information for equipment leaks at the Deepwater facility. Equipment leak emissions were calculated using model plant processes, and average Synthetic Organic Chemical Manufacturing Industry (SOCMI) values.[3,9] The emission rates for the Deepwater facility are given in Table 5.1-2. The calculations and data for the equipment leaks can also be found in appendicies C and D.

Table 5.1-2 Emissions of Ethyl Chloride fromTetraethyl Lead Production[a]

Du Pont facility located a Deepwater/Pennsville, New Jersey
Latitude[d] 39° 41' 24" N - Longitude[a] 75° 30' 28" W

Emission ID[b]	Estimated Emissions (kg/yr)
P-25	54
P-31	3,100
P-62	211,000
P-63	72,000
P-68	73
P-69	6,100
P-71	27
P-72	82
P-73	27
P-74	45
P-75	140
P-80	140
P-81-1	27
P-81-2	27
P-81-3	27
P-87-4	27
P-88	18
P-89-1	2,000
P-89-2	2,000
P-89-3	2,000
P-89-4	2,000
P-89-5	2,000
P-90-1	2,000
P-90-2	2,000
P-90-3	2,000
EL[c]	29,600
TOTAL	339Mg/yr

a. Letter from MP Polakavic, N.J. EPD, to G Hume, OAQPS, EPA. May 25, 1988. Computer Printout (dated May 24, 1988) for Ethyl Chloride Emissions from Du Pont's Chamber Works Facility.

b. P-process emission, EL-equipment leak.

c. U.S. Environmental Protection Agency, Fugitive Emission Sources of Organic Compounds-Additional Information on Emissions, Emissions Reductions, and Costs. EPA-450/3-82-010. Research Triangle Park, NC. April 1982. p.1-6.

5.1.2.2 Ethylcellulose and Ethylhydroxyethylcellulose. Due to the lack of available information on domestic production of these cellulose ethers and the few (2) production facilities in the U.S., process emissions were not estimated for this source category. However, equipment leak emission estimates were made using unadjusted, average SOCMI unit emission factors for the Model A type facility.[3] These values, along with the combined capacity for production, are listed in Table 5.1-3. Calculations follow in Appendix 8.8.

Table 5.1-3 Ethyl Cellulose: Estimated EtCl Equipment Leak Emissions

Company/ Site	Domestic* Consumption (10^6 lbs/yr)	Fugitive Emissions Estimate (Mg/yr)†
Dow Midland, Mi.	-	30
Hercules, Inc. Hopewell, Va.	-	30
Totals	8	60 Mg/yr

* Cellulose Ethers, Chemical Economics Handbook, SRI International, Menlo Park, CA, December 1984, p.581.5022X.

† obtained using SOCMI Model A emission factors

5.1.2.3 Ethylene Dichloride

Ethyl chloride is a reaction by-product of ethylene dichloride (EDC) production. The two main processes for EDC production are chlorination of ethylene and oxychlorination of ethylene. These processes can yield other chlorinated compounds such as 1,1,2-trichloroethane, perchloroehtylene, pentachloroethane, and others.[7] Ethyl chloride is a by-product of both of these processes. It is probably present due to the equilibrium position of the EDC reactions at the specific process conditions.

An unusual amount of ethyl chloride emissions data was available due to recent data collection and analysis for EDC emissions. Site specific data was used as much as possible. Detailed dispersion modeling parameters can be found in the appendicies.

To estimate ethyl chloride emissions from EDC production, a ratio of ethyl chloride to EDC was developed. This ratio was applied to estimates of EDC emissions from process vents. This ratio was also applied to equipment leaks. For some facilities equipment counts for EDC were available. These were developed into equipment leak estimates by using synthetic Organic manufacturing industry (SOCMI) average values.[3] For facilities without equipment counts, values for fugitive emissions of EDC were available and served as the basis for ethyl chloride equipment leak estimates.

Table 5.1-4 lists emission estimates for specific facilities. Specific calculations and devivations are given in the appendicies.

TABLE 5.1-4 Ethyl Chloride Emissions from EDC Production

Company Name/ Plant Location/ Emission Source	North Latitude (deg min s)	West Longitude (deg min s)	EtCl emission rate (kg/yr)
U.S. Industrial Chemicals	29 51 56	93 59 49	
Port Arthur, TX			
process			22
equipment leaks			10,700
BF Goodrich	37 02 50	88 19 20	
Calvert City, KY			
process			1,040
process			1,040
equipment leaks			36,900
BF Goodrich	29 46 00	95 05 00	
LaPorte, TX			
process			585
process			585
equipment leaks			36,900
Borden	30 12 20	91 01 08	
Geismar, LA			
process			21,000
equipment leaks			62,400
Diamond Shamrock	30 03 44	90 49 55	
Convent, LA			
process			22
equipment leaks			62,400
Diamond Shamrock	29 43 00	95 07 00	
Pasadena, TX			
process			21,000
equipment leaks			36,900

TABLE 5.1-4 Ethyl Chloride Emissions from EDC Production (cont.)

Company Name/ Plant Location/ Emission Source	North Latitude (deg min s)	West Longitude (deg min s)	EtC2 emission rate (kg/yr)
Dow Chemical	28 57 39	95 19 24	
Freeport, TX			
process			22
equipment leaks			7,850
Dow Chemical	28 58 00	95 21 00	
Oyster Creek, TX			
process			15,100
process			15,100
process			15,100
equipment leaks			51,400
Dow Chemical	30 19 46	91 14 21	
Plaquemine I, LA			
process			430
process			431
equipment leaks			145,000
Dow Chemical	30 19 46	91 14 21	
Plaquemine II, LA			
process			1985
process			1985
equipment leaks			41,500
Formosa	30 30 00	91 11 00	
Baton Rouge, LA			
process			18,600
equipment leaks			53,300

TABLE 5.1-4 Ethyl Chloride Emission from EDC Production (cont.)

Company Name/ Plant Location/ Emission Source	North Latitude (deg min s)	West Longitude (deg min s)	EtCl emission rate (kg/yr)
Formosa	28 41 04	96 32 12	
Point Comfort, TX			
process			198
process			199
equipment leaks			39,000
Georgia Gulf	30 16 30	91 10 30	
Plaquemine, LA			
process			5,950
process			5,950
equipment leaks			81,500
Olin Corporation	30 14 00	93 16 00	
Lake Charles, LA			
process			22
equipment leaks			16,700
PPG Industries	30 13 27	93 16 59	
Lake Charles, LA			
process			3,680
process			3,680
equipment leaks			23,000
Shell Chemical	29 43 04	95 07 53	
Deer Park, TX			
process			54
process			54
equipment leaks			53,000
Vista	30 15 04	93 17 00	
Westlake, LA			
process			10
process			11
equipment leaks			70,400
Vulcan Chemicals	30 11 30	90 58 27	
Geismar, LA			
process			25
process			26
equipment leaks			19,200
Total			982 Mg/yr

*Latitudes and longitudes are from Table 1. In: Dispersion Modeling Parameters for Ethylene Dichloride - EDC Case 1 in Memorandum from Marjorie Putnam, Midwest Research Institute, to Dave Beck, ESD, U.S. EPA, April 23, 1986. Estimates of Ethylene Dichloride Emissions from Production Facilities and HEM Inputs. References and other values are specified in Appencix G.

5.1.2.4 Polystyrene Foam Blowing

Ethyl chloride has only been used for foam blowing for a few years. It was chosen subsequent to extensive research for a blowing agent with the necessary characteristics.[14] Only one company is known to use ehtyl chloride in their polystyrene foam blowing process.[15] This company operates foam blowing units at six domestic facilities.

Ethyl chloride is a physical blowing agent. It does not react to form a gas; it vaporizes. Ethyl chloride can be emitted from process vents, equipment leaks, and during storage of the foam product. The largest quantities of emissions occur during storage.

Emission estimates for this category were based upon testimony given to the Illinois Pollution Control Board[14] and conversations with industry personnel.[15,16,17] A summary of the emissions is given in table 5.1-5. Calculation and more background data may be found in the appendicies.

5.2 Other Sources of Emissions

In addition to those from synthetic organic chemical manufacturing, ethyl chloride emissions have been detected from non-industrial sources. It was identified, along with other volatile organic compounds, at a hazardous waste site in New Jersey.[11] Although not a target compound, it was identified at one site 25-50 percent of the time, by mass spectrometry. Five locations were tested for VOC: two on-site, one bordering, two away from the site. One on-site test location contained leachate pools, while the border location was near a residential area.

Findings from another investigation show ethyl chloride vapors to result from the thermal oxidative degradation of coal mine combustion products.[12] Those included in the study were products of PVC and neoprene compositions, urethane rigid foams, and creosote (a coal tar distillate) treated pine.

Although ethyl chloride is available for use as a topical anesthetic in spray cannisters, data on emissions from this source were not available.

TABLE 5.1-5 - Ethyl Chloride Emissions from Polystyrene Foam Blowing[a]

Location[b] City, State	Longitude Latitude (° ' "N)(° ' "W)	Type of[c] Emission	Estimated Ethyl Chloride Emissions (mg/yr)
Allyn's Poing/ GalesFerry, CT	41 26 29/72 04 58	P	50
		F	20
		S	84
Dalton, GA[d]	34 46 06/84 57 42	P	70
		F	20
		S	120
Ironton, OH	38 31 00/82 40 00	P	70
		F	20
		S	120
Joliet, IL[e]	41 31 36/88 04 48	P	71
		F	20
		S	120
Pevely/ Riverside, MO	39 10 06/94 36 12	P	110
		F	20
		S	180
Torance, CA	33 51 02/118 19 49	P	20
		F	20
		S	36
Total			1170

a. All facilities are owned and operated by Dow Chemical U.S.A.

b. Telecon. Warila, B. Dow Chemical, with Hume, G. EPA, March 29, 1988. Ethyl Chloride Emissions from Foam Blowing.

c. P = process emission, F - equipment leaks
S = storage emissions

d. The Joliet emission estimates are based upon testimonies by DOW personnel for the Illinois Pollution Control Board Springfield, Illinois on February 10, 1987.

5.3 SHORT-TERM

Altnough attempts were made to secure such information, data on short-term emissions were not available at the time of this writing. Short term emissions are also refered to as acute releases. These emissions are those which significantly exceed the annual average for a specific time period, such as one hour.

5.4 REFERENCES

1. Data from Emissions Inventory, Texas Air Control Board, Austin, Texas, September 1986.

2. SRI International, Chemical Economics Handbook. Menlo Park, California. February 1988. p.646.5030 B

3. U.S. Environmental Protection Agency, Fugitive Emission Sources of Organic Compounds - Additional Information on Emissions, Emission Reductions, and Costs. EPA - 450/3-82-010. Research Triangle Park, North Carolina. April 1982. p.1-6, 2-70.

4. Letter from MP Polakovic, N.J. EPD, to G Hume, OAQPS, EPA. May 25, 1988. Computer Printout (dated May 24, 1988) for Ethyl Chloride Emissions from Du Pont's Chamber Works Facility.

5. Khan, Z.S., T.W. Hughes, Source Assessment: Chlorinated Hydrocarbon Manufacture, Office of Energy, Minerals and Industry, U. S. Environmental Protection Agency, Research Triangle Park, NC, August 1979, EPA 600/2-79-019, p.66.

6. Pervier, J.W., R.C. Bailey, et al., Survey Reports on Atmospheric Emissions for the Petrochemical Industry: Vol II, Office of Air and Water Programs, Office of Air Quality Planning and Standards, U. S. Environmental Protection Agency, Research Triangle Park, N.C. April 1974, EPA-450/3-73-005b, Table EDC-III.

7. SRI International, Chemical Economics Handbook. Menlo Park, California. September 1985. p. 651.5032 A.B.

8. Putnam, M., Estimates of Ethylene Dichloride Emissions from Production facilities and HEM Input, Office of Air Quality Planning and Standards, U. S. Environmental Protection Agency, Research Triangle Park, NC, April 23, 1986.

9. Direct communication with Leslie B. Evans, EPA. June 23, 1988. Complexity of ethyl chloride production and tetraethyl lead production processes.

10. LaRegina, J., J. Bozzelli, et al, Volatile Organic Compounds at Hazardous waste Sites and a Sanitary Landfill in New Jersey, Environmental Progress, Vol 5, No. 1, February 1986, pp.18-27.

6. REPORTS AND EXPERIMENTAL FINDINGS

6.1 AMBIENT AIR

Two reports were sponsored by the Agency in 1983 to measure and assess hazardous organic chemicals in the ambient atmosphere. The first of these reports measured atmospheric concentrations, variabilities, and mean diurnal behavior of 44 chemicals, including ethyl chloride. On-site field collection programs, based on single site studies of 9-11 days duration each, were conducted in 10 U.S. cities. Measurements were collected around-the-clock. It was theorized that the daily loss rate, i.e. percentage loss due to chemical reaction in the atmosphere, was low (3.3 percent) for ethyl chloride becouse it is relatively unreactive. The hydroxyl radical (OH) reaction rate constant was given as 0.39×10^{-12} cm^3 $molec^{-1} s^{-1}$ at 300K.[1]

The average ethyl chloride concentrations at most sites was 0.1 ppb or less. The exception was Houston whose average and maximum levels were 0.23 and 1.3 ppb, respectively. The maximum concentrations at the other sites did not exceed 0.32 ppb. Background concentrations of ethyl chloride (at 40°N latitude) were also reported and lie in the range of 10-15 ppt.[1]

In a follow-up report, data were collected on 151 chemicals from a variety of sources between 1970 and 1980. The data were classified according to data quality, and tnen analyzed to assess their reliability and usefulness in concentration trend analysis. For the hazardous organic chemicals of this study, relatively little information was available with which health assessments or trend analysis could have been confidently made. Most data were limited to a few geographic regions and had been collected during the daylight hours of warmer months.[2]

The same study group investigated concentrations of ethyl chloride over the eastern Pacific Ocean (1981). Within 0-40°N latitude over the northern and southern hemispheres, weighted average concentrations (ppt) were 19 and <5, respectively. Etnyl chloride was not detectable south of 10°N. The global average was reported at 10 ppt.[3]

6.2 EXPOSURE DATA

6.2.1 Standards

The exposure levels of ethyl chloride adopted by the U.S. Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH) are provided in Table 6.2-1.

Table 6.2-1 Ethyl Chloride Exposure Limits

OSHA Standard	ACGIH Guideline Standard
PEL†	TLV®*
1000 ppm 2600 mg/m^3	1000 ppm 2600 mg/m^3

All figures are for an 8-hour time weighted average (TWA)
† Permissible Exposure Limit
* Threshold-Limit Value

6.2.2 Survey Report

An industrial hygiene survey was conducted at a tetraethyl lead facility (Ethyl Corporation, Pasadena,Texas) in April of 1980 sponsored by the U.S. National Institute for Occupational Safety and Health (NIOSH).[4] Personal and area samples were collected for TEL and ethyl chloride, as well as for three other pollutants. The ethyl chloride personal samples averaged 0.425 mg/m^3, well below the 2600 mg/m^3 OSHA and ACGIH levels. Samples were collected for 6-8 hours per shift using two charcoal tubes in series followed by MDA Accuhaler (Model 808) low flow pumps. A modified NIOSH Method S-105 was employed to analyze the samples. Statistics were generated by job title, but were not fully descriptive of the exposure data.

6.3 AQUEOUS EMISSIONS

A February 1979 report investigated the presence of organic compounds in industrial effluent discharges.[5] Samples taken from 63 effluent and 22 intake waters from a wide range of chemical manufacturers, were preconcentrated for four-part organics analysis: volatile organics by helium-gas stripping and semivolatile organics by extraction with methylene chloride, resulting in separate neutral, acidic and basic fractions. A total of 570 compounds were tentatively identified. The identifications were labeled "tentative" because they were limited by "purity" of sample component mass spectrum and data base accessibility of individual compound spectra. Of the 63 samples, ethyl chloride was identified once at a concentration between 10-100 ug/l and twice at levels ≤10 ug/l.[5]

The evaporative half-life of ethyl chloride in water was experimentally found to be 23.1 min.[6] Half-lives of 0.50 and 16.7 mins were also reported.[7] With a partition coefficient of 0.46, and the above reported half-lives, it is possible that ethyl chloride evaporates relatively quickly from an aqueous environment, leaving very small, if any, concentrations in effluent waters.

REFERENCES

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2. Brodzinsky, R., H.B. Singh, Volatile Organic Chemicals in the Atmosphere: an Assessment of Available Data, Office of Research and Development, U. S. Environmental Protection Agency, Research Triangle Park, NC, EPA-600/3-83-027A, April 1983.

3. Singh, H.B., L.J. Salas, et al. Selected Man-made Halogenated Chemicals in the Air and Oceanic environment, Journal of Geophysical Research, Vol 88, No. 6, 1983.

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5. Perry, D.L., C.C. Chuang, et al, Identification of Organic compounds in Industrial Effluent Discharges, Office of Toxic Substances, U. S. Environmental Protection Agency, Washington, D.C., February 1979, EPA-600/4-79-016, p.43.

6. Dilling, W.L., Interphase Transfer Processes. II. Evaporative Rates of Chloro-Methanes, Ethanes, Ethylenes, Propanes, and Propylenes from Dilute Aqueous Solutions. Comparisons with Theoretical Predictions, Environmental Science and Technology, Vol III, No. 4, April 1977, pp.405-409.

7. Dilling, W.L., Atmospheric Environment, Environmental Risk Analysis for Chemicals, R.A. Conway, editor, Van Nostrand Reinhold, New York, NY, 1982, p.173.

7. UNCERTAINTIES AND FUTURE WORK

The emission estimates calculated in this assessment are annual approximations. Site-specific information is usually not available. These estimates were based upon the most appropriate of the available data and conservative assumptions. A conservative assumption results in higher emission and concentration estimates in the ambient air.

APPENDICES

A. Ethyl Chloride Synonyms

B. Ethyl Chloride Imports and Exports

C. Ethyl Chloride Production

D. Tetraethyl Lead (TEL) Production

E. Ethylcellulose (EC) Production

F. Polystyrene Foam Blowing

G. Ethylene Dichloride (EDC) Production

H. Human Exposure Model (HEM) Inputs

A. CAS No. 75-00-3

Chloroethane
Monochloroethane
Chlorethyl
Ether Hydrochloric
Ether Muriatic
Ether Chloratus
Aethylis Chloridum
Kelene
Chelene

The Merck Index 10th edition, p. 548

APPENDIX B. ETHYL CHLORIDE IMPORTS AND EXPORTS

ETHYL CHLORIDE IMPORTS

Yearly figures are given below:

Year	Imports	
	10^3 lbs	Mg
1964	1.91	0.86
1966	1.27	0.58
1967	2.32	1.05
1969	1.10	0.50
1970	2.14	0.97
1971	1.10	0.50
1972	2.36	1.07
1973	0.66	0.30
1974	2.78	1.26
1975	4.92	2.13
1976	0.22	0.10
1977	1.32	0.60
1978	2.89	1.31
1979	3.47	1.57
1980	2797.81	1269.08
1981	11079.39	5025.58
1982	5121.54	2323.12

1964-79 - All imports from Federal Republic of Germany (FRG)
1980 - All imports from Canada
1981 - 99 percent of imports from Canada; 1 percent FRG and Switzerland

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Chemical Economics Handbook, Ethyl Chloride: Salient Statistics, SRI International, Menlo Park, California, 1983, p.646.5030E.

E ETHYL CHLORIDE EXPORTS

Year	Exports		
	10^6 lbs	10^3 Mg	10^3 dollars
1978	28.15	12.77	4.46
1979	28.04	12.72	4.94
1980	26.18	11.88	5.51
1981	26.87	12.19	5.82
1982	26.46	12.00	5.44

1981 - 86 percent of exports received by Mexico.
1982 - 94 percent of exports received by Mexico.

Chemical Economics Handbook, Ethyl Chloride: Salient Statistics, SRI International, Menlo Park, California, 1983, p.646.5030E-F.

APPENDIX C. ETHYL CHLORIDE PRODUCTION

Production Estimates:

1984 total capacity = 460 million lbs.

1984 total production = 290 million lbs.

1984 production factor = $\frac{\text{production}}{\text{capacity}}$ = 0.63

1985 total capacity = 460 million lbs.

1985 total production = 170 million lbs.

1985 production factor = 0.37

1986 total capacity = 470 million lbs.
1986 total production = 157 million lbs

1986 estimated production factor = 0.33

1987 total capacity = 395 million lbs.
1987 estimated production = 164 million lbs.

1987 estimated production factor = 0.42

Annual Change in Production:

1980-81 = -18%
1981-82 = +5%
1982-83 = -17%
1983-84 = +4%
1984-85 = -41%
Estimated 1986-87 = +5%

Calculation of Emission Factor from Production:

Process: Hydrochlorination of Ethylene

Two process vents, each with 34818 kg ethyl chloride emissions per year

Basis: Process vent emission rates* Ethyl Corporation
Pasadena, Texas

Two process vents, each with 34818 kg ethyl chloride emissions
1986 capicity = 160 million lbs.

*Data from Texas Air Control Board Emission Inventory, September 1986

Since production figures were not available at specific sites, the process emission factor was based on the 1986 emission data and capacity for Ethyl Corporation at Pasadena, Texas. Process emissions are a function of throughput, so an underlying assumption used here is that all facilities operated at the same production/capacity rate as Ethyl Corporation Industry-wide, this rate was 0.33 in 1986.

$$\text{Capacity} = 160 \times 10^6 \text{ lb/yr} \times 0.4536 \text{ kg/lb} = 72.6 \times 10^6 \text{ kg/yr.}$$

$$= 72.6 \text{ Gg/yr.}$$

Emission Factor

$$\frac{\text{total emissions}}{\text{capacity}} = 2 \times \frac{34818 \text{ kg/yr}}{72.6 \text{ Gg/yr}} = 960 \text{ kh/Gg}$$

= 480 kg/Gg at each of two process vents.

A specific value for process emission velocity for hydrochlorination of ethylene was not available. Because of this, a value which was considered to be in a reasonable range (2500-3000 fpm) was chosen.[1] The calculation for converting to metric units is given below.

$$\frac{2500 \text{ feet}}{\text{min}} \left| \frac{1 \text{ min}}{60 \text{ sec}} \right| \frac{1 \text{ meter}}{3.281} = 13 \text{ meters/sec}$$

Calculation of Emission Factor from Production (Continued):

It was assumed that, like the Ethyl Corporation facility, each facility would have two process vents emitting equal quantities. Two of the facilities do not manufacture ethyl chloride by hydrochlorination of ethylene. However, no specific process values or emission factors were available to quantify ethyl chloride emissions from other processes. Therefore, it was assumed that the process emissions and equipment leaks would be the same as for the hydrochlorination process.

Table C-1 Ethyl Chloride Emissions from Ethyl Chloride Production[a]

Company/ Location	Process Sources[b]	Capacity[c] (Gg/yr)	Emission Factor[b] (kg/vent/Gg capicity)	Emissions (Mg/yr)
Dow Chemical U.S.A. Freeport, TX	P1	4.54	480	2.18
	P2		480	2.18
	EL		---	29.6
E.I. du Pont de Nemours & Co., Inc. Deepwater, NJ	P1		480	21.8
	P2	45.4	480	21.8
	EL		---	29.6
Ethyl Corporation Pasadena, TX	P1	72.6	480	34.8
	P2		480	34.8
	EL		---	29.6
PPG Industries Lake Charles, LA	P1	56.7	480	27.2
	P2		480	27.2
	EL		---	29.6
TOTALS		179	960 kg/Gg	290.4

a. Process is assumed to be hydrochlorination of ethylene. This process is actually in use only at the Ethyl and PPG facilities. References indicate that Dow capacity is a by-product of vinyl chloride production or a product of direct reduction of vinyl chloride. Du Pont capacity is a by-product of Freon® manufacture and actual production is well below stated capacity.

b. Process vents are assumed to emit equal proportions of total process emissions.

c. SRI International, Chemical Economics Handbook, February 1988. p.646.5030 B.

Equipment counts and other equipment leak data were not available for the ethyl chloride production process. A model plant was the basis of the equipment leak estimate. To determine the most appropriate model plant, the number of pumps in the process were estimated and compared with the number of pumps in the three models. Model Plant A has eight pumps in light liquid service and seven pumps in heavy liquid service; Model B has thirty and thirty; Model C has ninety-two and ninety-three, respectively.[2]

The number of pumps in the ethyl chloride production process (hydro chlorination of ethylene) was estimated after a review of a flow diagram and a process description.[3] Allowances were made for industry norms for equipment redundancy. A total of sixteen pumps, ten in light liquid service and six in heavy liquid service, were estimated.[4] This estimate indicated that Model Plant A was most appropriate.

Since the main product of this process is ethyl chloride, it was assumed that 100 percent of the emitted VOC was ethyl chloride. The equipment leak estimate for these plants totalled 29.6 Mg/yr.

Not all four of the production facilities use ehtylene hydro-chlorination to produce ethyl chloride. Two of the facilities obtain ethyl chloride as a by-product from other processes. The hydrochlorination process is thought to be more complex than the ethyl chloride separation units of the other processes. Therefore, the Model Plant A is an appropriate model for all four production plants.

Calculation of Emission Factor For Equipment Leaks

Table C-2 Equipment Leak Factors and Equipment Leaks

	Number of Sources* for Model Unit A	Emission Factor (kg/hr/source) (kg/m/source)	Emission Rate (kg/hr) (kg/m)	Ann Emissions** (kg/yr) (kg/yr)
Pump Seals				
Light liq.	8*	0.0494	.395	3462
Heavy liq.	7	0.0214	.150	1312
Valves				
Gas	99	0.0056	.554	4857
Light liq.	131	0.0071	.930	8148
Heavy liq.	132	0.00023	.030	266.0
Safety/relief valves				
Gas	3	0.1040	.312	2733
Open-ended lines	104	0.0017	.177	1549
Compressor Seals	1	0.228	.228	1997
Sampling connections	7	0.0150	.105	919.8
Flanges	600	0.00083	.498	4362
TOTAL			3.38	29600 kg/yr

* Environmental Protection Agency Fugitive Emission Sources of Organic Compounds- Additional Information on Emissions, Emission Reductions, and Costs. EPA-450/3-82-010, Research Triangle Park, North Carolina, April 1982. p.1-6, 2-70.

**Hours of operation assumed to be 8760/yr., i.e., continuous operation assumed.

Transportation and Storage Emissions:

Due to the volatility of ethyl chloride, it is usually stored in pressurized tanks. Data have indicated that no emissions result from such storage methods.[5] Transporation losses are expected to occur only during connection and disconnection for actual transfer. They are expected to be minimal. Actual data are unavailable.

. American Conference of Governmental Industrial Hygienists, Industrial Ventilation: A Manual of Recommended Practice, 14th ed. ACGIH. Lansing, Michigan, 1977. p. 6-23.

2. Environmental Protection Agency, Fugitive Emission Sources of Organic Compounds-Additional Information on Emissions, Emission Reductions, and Costs. EPA-450/3-92-010. Research Triangle Park, NC, April 1982. p. 1-6.

3. Environmental Protection Agency, Draft Report: Ethyl Chloride Prelimiary Source Assessment. April 25, 1988. p.2-1, 2-3, 2-4.

4. Direct communication with Leslie B. Evans, EPA. June 23, 1988. Complexity of ethyl chloride production and tetraethyl leak production processes.

5. Data reported from Emissions Inventory: Rhone-Poulenc, Inc. (Freeport, TX), Texas Air Control Board, Austin, TX, September 1986.

APPENDIX D. TETRAETHYL LEAD (TEL) PRODUCTION

Table D-1. Annual TEL Production

Year	Annual Production[a] TEL (10 lbs)	Annual Production[a] Other Lead Alkyls[b] (10 lbs)	Annual Consumption[a] Lead Alkyls (10 lbs)
1967	555	299	624
1968	485	460	657
1969	371	506	688
1970	325	504	688
1971	281	-	655
1972	302	670	670
1973	353	763	659
1974	464	455	578
1975	315	353	520
1976	364	-	557
1977	327	553	528
1978	328	463	496
1979	412	433	421
1980	325	192	248
1981	275	132	196
1982	224	130	204
1983	-	106	161
1984	-	107	146
1985	-	-	61
1986	-	-	31

[a] SRI International, Chemical Economics Handbook, Menlo Park, California, September 1986. p. 543.7051 S,U.

[b] Includes tetramethyl lead (TML), tetramethyethyl leads, organolead compounds (1972), and mixed lead alkyl compounds (1973-1975).

Tetraethyl lead is produced domestically at one site. The production unit is owned and operated by DuPont at their Deepwater/ Pennsville, New Jersey facility.

The emissions data which were obtained from the New Jersey Department of Environmental Protection included emission rates and stream characteristics for process emissions.[1] This date also contained a value for the radius of the emission area.

The number of process emission points (see Table 1) might be taken as an indication of a complex process. In fact, these emissions are probably not emitted exclusively from the TEL production unit. Ethyl chloride is produced at this Du Pont facility. It is likely that it is used in other processes. The ethyl chloride process emissions given are the facility wide totals. Which emissions come specifically from the TEL production unit is not known. The conservative assumption that was used was that all of the process vents are from the TEL production unit.

Equipment counts and other equipment leak data were not available for the tetraethyl lead production process. A model plant was the basis of the equipment leak estimate. To determine the most appropriate model plant, the number of pumps in the process were estimated and compared with the number of pumps in the three models. Model Plant A has eight pumps in light liquid service and seven pumps in heavy liquid service; Model B has thirty and thirty; Model C has ninety-two and ninety-three, respectively.[2]

Table D-2 Emissions of Ethyl Chloride from Tetraethyl Lead Production[a] Du Pont facility located at Deepwater/Pennsville, New Jersey

Latitude[d] 39° 41' 24" N - Longitude[a] 75° 30' 28" W

Emission ID[b]	Stack Height (m)	Stack Diam (m)	Flow Rate (m^3/s)	Velocity[e] (m/s)	Temp (K)	Estimat Emission (kg/yr)
P-25	16	0.40	1.22	9.7	294	54
P-31	9	.003	.097	1[f]	294	3,100
P-62	38	.46	.047	0.28	294	211,000
P-63	40	.40	1.09	8.7	294	72,000
P-68	7.6	.24	.24	5.3	294	73
P-69	49	.43	.52	3.6	294	6,100
P-71	26	.9	8.5	13	294	27
P-72	27	1.1	12.3	13	294	82
P-73	38	.06	.0005	0.18	294	27
P-74	38	.030	.002	2.8	333	45
P-75	27	1.1	12.3	13	294	140
P-80	21	.30	0.99	14	294	140
P-81-1	38	.61	.19	0.65	294	27
P-81-2	38	.61	.19	0.65	294	27
P-81-3	38	.61	.19	0.65	294	27
P-87-4	38	.61	.19	0.65	294	27
P-88	9	.24	.28	6.2	294	18
P-89-1	7.6	.03	.006	8.5	294	2,000
P-89-2	7.6	.03	.006	8.5	294	2,000
P-89-3	7.6	.03	.006	8.5	294	2,000
P-89-4	7.6	.03	.006	8.5	294	2,000
P-89-5	7.6	.03	.006	8.5	294	2,000
P-90-1	11	.03	.006	8.5	294	2,000
P-90-2	11	.03	.006	8.5	294	2,000
P-90-3	11	.03	.006	8.5	294	2,000
EL[c]	3.0	(3,142,000 m^2 area)		.01	298	29,600
TOTAL						339,Mg/yr

a. Letter from MP Polakavic, N.J. EPD, to G Hume, OAQPS, EPA. May 25, 1988. Computer printout (dated May 24, 1988) for Ethyl Chloride Emissions from Du Pont's Chamber Works Facility.
b. P-process emission, EL-equipment leak.
c. Stream characteristics, except for area, are default values.
d. U.S. Environmental Protection Agency, Fugitive Emission Sources of Organic Compounds-Additional Information on Emissions, Emission Reductions, and Costs. EPA-450/3-82--1-. Research Triangle Park, NC. April 1982. p. 1-6.
e. Flow rate (diam/2)2
f. Where the data were insufficient or yielded unreasonable answers, a default value of 1m/s was used.

The number of pumps in the tetraethyl lead production process was estimated after a review of a flow diagram and a process description.[3] Allowances were made for industry norms for equipment redundancy. Seven pumps, each with a back-up pump, were estimated for a total of fourteen pumps in the TEL production.[4] This estimate indicated that Model Plant A was the most appropriate model.

Since ethyl chloride is a major component of the process, and because stream composition data were not available, it was assumed that 100 percent of the emitted VOC was ethyl chloride. The equipment leak estimate at the facility totalled 29.6 Mg/yr. See Appendix C, table C-2 for more details on this model facility calculations.

The necessary parameters for the human exposure model (HEM) are given in Table D-2.

1. Letter from MP Polakovic, N.J. EPD, to G Hume, OAQPS, EPA. May 25, 1988. Computer Printout (dated May 24,1988) for Ethyl Chloride Emissions from Du Pont's Chamber Works Facility.

2. U.S. Environmental Protection Agency, Fugitive Emission Sources of Organic Compounds-Additional Information on Emissions, Emission Reductions, and Costs. EPA-450/3-82-010. Research Triangle Park, NC. April 1982. p. 1-6.

3. Environmental Protection Agency, Draft Report: Ethyl Chloride Prelimnary Source Assessment. April 25, 1988. p. 3-1 through 3-5.

4. Direct communication with Leslie B. Evans, EPA. June 23, 1988. Complexity of ethyl chloride production and tetraethyl lead production processes.

APPENDIX E. ETHYLCELLULOSE (EC) PRODUCTION

Domestic Consumption of Ethyl Cellulose (EC) and Ethylhydroxyethylcellulose (EHEC)

Year	1965	1969	1973	1976
Millions of pounds	8	9	7	7

Chemical Economics Handbook, Cellulose Ethers, SRI International, Menlo Park, California, November 1977, p.584-5022J.

Due to lack of process information on ethyl cellulose and ethyl hydroxy ethyl cellulose manufacture, process emissions were not estimated. Equipment leaks were estimated using SOCMI average emission factors for Model Unit A.

The procedure used for estimation of equipment leaks is identical to to that for ethyl chloride production facilities. For more information on this calculation see Appendix C, Table C-2.

Company/location	Fugitive Emissions (Mg/yr)
Dow Chemical Co. Midland, Michigan	29.6
Hercules, Inc.	29.6
TOTAL	59.2

APPENDIX F. POLYSTYRENE FOAM BLOWING

Ethyl chloride is used as a foam blowing agent by one company at six domestic sites. All of the information regarding this use has come from testimonies of company personnel for the Illinois Pollution Control Board[1] and from direct contact with company personnel.[2,3,4]

The testimonies given were related to (1) "generic rules" regarding emission standards of organic materials and (2) emissions of ethyl chloride at the Joliet, Illinois facility.

The three main emission types were identified as:

1) Emissions during outdoor storage of the polystyrene foam product - 137 tons/yr of ethyl chloride.

2) Equipment leaks - 22 tons/yr of ethyl chloride.

3) Process emissions - 78 tons/yr of ethyl chloride.

Equipment leaks are primarily a function of the amount and types of equipment involved in a process. Because the same company operates all of these facilities and because site specific equipment counts were unavailable, it was assumed that similar process equipment is used at all sites. Based upon the Joliet data, 20 Mg/yr of ethyl chloride are emitted through equipment leaks.

$$\frac{22 \text{ tons}}{\text{yr}} \left| \frac{2000 \text{ lbs}}{\text{ton}} \right| \frac{0.4536 \text{ Mg}}{1000 \text{ lbs}} = 20 \text{ Mg/yr}$$

To assist in estimating storage and process emissions at the other facilities, company personnel estimated emissions at each site relative to the emissions at Joliet. This information can be found in Table F-1.

Table F-1 - Ethyl Chloride Emissions from Styrofoam® Production[a]

Location[b] City, State	Longitude/ Latitue (°'"N)(°'"W)	Process & Storage[c] Emissions (% relative to Joliet facility)	Type of Emission[d]	Estimated Ethyl Chloride Emissions (Mg/yr)
Allyn's Point/ GalesFerry, CT	41 26 29/72 04 58	70	P EL S	50 20 84
Dalton, GA	34 46 06/84 57 42	100	P EL S	70 20 120
Ironton, OH	38 31 00/82 40 00	100	P EL S	70 20 120
Joliet, IL[e]	41 31 36/88 04 48	--	P EL S	70 20 120
Pevely/ Riverside, MO	39 10 06/94 36 12	150	P EL S	110 20 180
Torrance, CA	33 51 02/118 19 49	30	P EL S	20 20 36
Total				1170

a. Styrofoam is a registered trade mark of a Dow Chemical U.S.A. polystyrene foam product.

b. Telecon. Warila, B. Dow Chemical, with Hume, G. EPA, March 29, 1988. Ethyl Chloride Emissions from Foam Blowing.

c. ibid. Estimates are given relative to those from the Joliet, IL facility.

d. P = process emission, EL = equipment leaks, S = storage emissions.

e. The Joliet emission estimates are based upon testimonies by Dow Chemical U.S.A. personnel (R.S. Thompson, Kyung W. Suh, Steve West, Patrick F. Carrera), for the Illinois Pollution Control Board in Springfield, Illinois on February 10, 1987.

Table F-2. Emission Stream Characteristics

Type of Emission	Release Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temperature (K)	Release Area (m^2)	Duraation[a] (hrs)
Process[b]	10	1.1	14	300	--	C
Fugitive	1	--	.01	300	--	C
Storage	3	--	.01	300	21000[c]	C

a. C = continuous (8,760 hours)
b. Telcon. Warila, B. Dow Chemical U.S.A. with Hume, G., EPA, March 29, 1988. Ethyl Chloride Emissions from foam blowing.
c. Based upon testimonies by Dow personnel for the Illinois Pollution Control Board, February 10, 1987.

1. Testimonies of R.S. Thompson, Kyung W. Suh, Steve West, and Patrick F. Carrera, Dow Chemical U.S.A., before the Illinois Pollution Control Board, Springfield, IL on February 10, 1987.

2. Telecon. Steve Rose, Dow Chemical U.S.A. with Gretchen Hume, EPA, September 18, 1987. Ethyl Chloride Use in Polystyrene Form Blowing.

3. Telecon. Steve Rose, Dow Chemical U.S.A. with Gretchen Hume, EPA. March 28, 1988. Ethyl Chloride for Foam Blowing.

4. Telecon. Bob Warila, Dow Chemical U.S.A. with Gretchen Hume, EPA. March 29, 1988. Ethyl Chloride Emissions from Foam Blowing.

APPENDIX G. ETHYLENE DICHLORIDE (EDC) PRODUCTION

The predominant processes for domestic ethylene dichloride (EDC) production are chlorination of ethylene and oxychlorination of ethylene. EDC emissions have been evaluated recently by the EPA.[10] This evaluation made much more data than usual available for this preliminary evaluation of ethyl chloride emissions. How the EDC data and other data were used to evaluate ethyl chloride emissions is detailed in this appendix.

The first step in making use of the EDC data was to determine an ethyl chloride: EDC ratio. The process emissions and equipment leaks of EDC were then evaluated and multiplied by the ratio. This resulted in emission estimates for ethyl chloride.

The ethyl chloride dispersion modeling parameters are assembled in table G.4-1, toward the end of this appendix. The eighteen domestic EDC production facilities emit an estimated 982 Mg/yr of ethyl chloride.

G.1 Calculation of Ratio of Ethyl Chloride to Ethylene Dichloride

The ratio of ethyl chloride (EtC) to ethylene dichloride (EDC) was based on composition data for uncontrolled emissions from oxychlorination and direct chlorination process vents.[1] These data were combined because information specifying the process or processes currently in use at all facilities was not available. The EtCl:EDC ratio was used for both process emissions and equipment leaks because no information concerning composition of equipment leaks at EDC production facilities was found.

Of ten facilities reporting compositions, one facility did not report a composition estimate for either EtCl or EDC. Data from that facility could not be used. The remaining nine data sets had values for E+Cl or VOC and EDC.

Of these data sets (see Table 3), one facility reported composition in percent. Molecular weights were used to convert the mole percent to weight fractions (see Figure 1). The remaining eight data sets were reported in weight percents or pounds per hour which could both be converted directly to weight fractions.

TABLE G.1-1 COMPOSITIONS REPORTED FROM PROCESS VENTS FOR EDC PRODUCTION

Facility Units Component	A (wt %)	B (lb/hr)	C (wt %)	D (16/hr)	E (wt %)	F (wt %)	G (mole %)	H (lb/hr)	I (lb/hr)
EDC	3.03	414	0.75	130	5	4.6	1.7	74.4	200
Ethyl Choride	0.92	489	1.00	0.59	5	2.1	0.01	----	---
Ethylene	----	117	0.02	119	44	0.8	3.3	183.1	318
Other VOC	6.53	60	0.23	0.75	---	2.6	0.02	2.45	68

1. U.S. Environmental Protection Agency, Report 1: Ethylene Dichloride in: Organic Chemical Manufacturing, Volume 8. Selected Processes, EPA-450/3-80-028c. December 1980. p. F-4,5.

Component	Molecular Weight
EDC	98.96
EtCl	64.52

$$0.01 \text{ mole EtC} \mid \frac{64.52 \text{ g EtCl}}{\text{mole}} = 0.6452 \text{ g EtC}$$

$$\frac{0.6452 \text{ g EtCl}}{168.23 \text{ g EDC}} = 0.0038 \text{ weight fraction EtC:EDC}$$

Figure G-1. Converting Mole Percent to Weight Fraction

All of the data sets used had estimates for EDC. Seven of the eight had estimates for EtCl but, two data sets were missing values for EtCl. Both of these sets did have values the component "other VOC". For these two sets, the ratio of EtCl to EDC was obtained through ratios of these components to volatile organic compounds (VOC). For simplicity, it was assumed that VOC would be comprised of the chemicals: ethyl chloride, ethylene, and other VOC where these data were available. The ratio for ethyl chloride to VOC was based upon the composition data in six data sets. The seventh data set, given in mole percent, could not be used because the molecular weight for the category "other VOC" was unknown.

Table G.1-2 Ratio of EtC to VOC

Facility Units	A (wt%)	B (lb/hr)	C (wt%)	D (lb/hr)	E (wt%)	F (wt%)	avg ± std. dev.
Component							
ethyl chloride	0.92	489	1.00	0.59	5	2.1	--
VOC	7.45	666	1.25	120.34	49	5.5	--
$\frac{EtCl}{VOC}$	0.123	0.734	0.800	0.0049	0.102	0.382	0.358 ± 0.341

The ratio of ethyl chloride to VOC was multiplied by the weight fraction of VOC to ethylene dichloride to determine an E+CI to EDC weight fraction for the two incomplete data sets.

Example for facility H -

$$\frac{0.358 \text{ EtCl}}{1 \text{ unit VOC}} \left| \frac{2.45 \text{ (lb/hr) VOC}}{74.4 \text{ (lb/hr) EDC}} \right. = 0.0118 \text{ EtCl/unit EDC}$$

Figure G-2 - Obtaining the EtCl to EDC ratio via the EtCl to VOC and VOC to EDC ratios.

The weight fractions of EtCl to EDC were determined for all nine facilities. The average EtCl:EDC ratio was 0.490 with a standard deviation of 0.538.

Table G. 1-3 Ratios of EtCl to EDC (wt. fraction: 1)

facility -	A	B	C	D	E	F	G	H	I	avg±std dev.
EtCl:EDC	0.304	1.18	1.33	0.005	1.00	0.457	0.0038	0.0118	0.122	0.490 ± 0.538

This value was based upon process vent compositions. As indicated by the large standard deviation, the ratio varied greatly among the different facilities. Details were not available of how these original composition values (see Table D.1-1) were obtained (i.e. whether they were obtained through stack testing, mass balances, engineering judgement, etc.) It was decided that using the average ratio for all facilities would yield the best overall estimates.

G.2 Ethyl Chloride Emissions from Process Vents at Ethylene Dichloride Production Facilities

The only data avalilable for process emissions from ethyl dichloride (EDC) production facilities was generally specific to EDC emissions. Since specific ethyl chloride (EtCl) data were not available, it was assumed that ethyl chloride would be emitted at a rate proportional to the EDC rate from the same process points as the EDC, i.e. the same vents, stacks, etc.

The following sections detail the calculations for EDC process emissions. These emission estimates were based upon data from responses to 114 questionnaires.[2,3,4,5,6,7,8] A 114 questionnaire is a request for emission information which is sent to a company by the U.S. EPA. The authority to obtain the information is provided by section 114 of the Clean Air Act.

Site specific information was not available for all EDC production facilities. However, from those that were provided, emission estimates had been made for all facilities for the EDC project.[9]

G.2.1 EtCl Process Emission Rates

The process emission rates of EtCl for all facilities were based upon summaries of EDC process emissions (see table G.2-1). EDC emissions from all process vents were totaled and multiplied by the EtCl:EDC ratio. The EtCl total was then divided by the number of process vents. In some cases, it was assumed that two process vents were present. Two was the average number of process vents per facility recorded on the EDC emission summary. The following section details the other emission stream characteristics, such as temperature and release height.

For facilities with more than one process vent listed it was necessary to assume an equal emission rate from all vents. The assumption was made because it was not possible to correlate the specific stream characteristics with the appropriate emission rates.

Table G.2-1 Total EDC and EtCl emissions from process vents

Company	Location	estimated EDC emissions[a] (kg/yr)	estimated EtCl emissions[b] (kg/yr)	number of process vents for EDC emissions[a]
U.S. Industrial Chemicals	Port Arthur, TX	45	22	1
BF Goodrich	Calvert City, KY	4247	2080	7
BF Goodrich	LaPorte, TX	2390	1170	3
Borden	Geismar, LA	42925	21000	1
Diamond Shamrock	Convent, LA	45	22	1
Diamond Shamrock	Pasadena, TX	42925	21000	1
Dow Chemical	Freeport, TX	45	22	1
Dow Chemical	Oyster Creek, TX	92405	45300	3
Dow Chemical	Plaquemine I, LA	1757	861	2
Dow Chemical	Plaquemine II, LA	8110	3970	1
Formosa	Baton Rouge, LA	38000	18600	1
Formosa	Point Comfort, TX	810	397	2
Georgia Gulf	Plaquemine, LA	24280	11900	3
Olin Corp	Lake Charles, LA	45	22	1
PPG Industries	Lake Charles, LA	15030	7360	4
Shell Chemical	Deer Park, TX	220	108	2
Vista	Westlake, LA	42.54	21	8
Vulcan Chemicals	Geismar, LA	105	51	2
Total		273,430	133,900	44
avg$\pm$std.dev.		--	--	2.4$\pm$2.1

a. Values obtained from Memorandum, M. Putnam, Midwest Research Institute to D. Beck, OAQPS, EPA, Estimates of Dichloride Emissions from Production Facilities and HEM Inputs. April 23, 1986.p.5-11

b. Weight fraction EtC:EDC = 0.49:1.0 (see section G.1)

G.2.2. EtCl Process Emission Stream Characteristics

The values for the stream characteristics, such as stack height and vent diameter, were based either on non-confidential responses to 114 questionnaires or on the EDC memorandum (references 2-9). These non-confidential data were compiled to obtain average values. Average or typical values from the EDC emission memorandum were also used. Table G.2-2 lists the values which were obtained from 114 responses and the average values which were derived from them. When data necessary to determine velocity of the process stream were not available, the value 7.9 m/s was used. This value was taken from the EDC memorandum.[9]

Table G.2-2 Process Emission Stream Characteristics*

facility	vent no.	area	height (m)	diameter (m)	flow rate (acfm)	temperature (°C)
A	1	-	15.24	0.46	100	25
B	1	-	7.32	0.05	3.59	29.5
C	1	-	7	0.67	95	40
	2		18.3	0.76	135	40
	3		17.2	0.71	1440	40
D	1	500'x500'	15.24	0.762	145	-5
	2		-	0.762	730	-5
E	1	1367000ft^2	15.2	0.61	629	50
	2		15.2	0.61	272	-5
F	1	450'x600'	22.9	0.61	5018	7-66
G	1	100'x100'	-	-	-	-
H	1	-	25.9	0.75	-	20
I	1	-	44.2	0.90	130	-12
	2				54	59
	3				9	51
	4				2.1	57
	5				26.4	38
	6				14.8	64
	7				-	-
	8				-	-
J	1	200'x300'	15.2	.15	4824	10
total n(number of data points)		5	11	11	17	18
x±sigma		36400 ± 51800m^2	18.5±10.2	0.58±0.27	802±1595	29.6±24.2

*reference 2-8

G.3 Ethyl Chloride Emissions from Equipment Leaks at Ethylene Dichloride Production Units.

The ethyl chloride equipment leak emissions were based upon site specific equipment counts or ethylene dichlorice (EDC) fugitive emission estimates. The equipment counts were given in responses to 114 questionnaires. The 114 equipment counts were analyzed to develop weighted total, or 100 percent EDC equivalent, equipment counts for each site. The counts were multiplied by average synthetic organic chemical manufacturing industry (SOCMI) emission factors and prorated with the EtCl:EDC weight fraction.

Where site specific equipment counts were unavailable, estimates for fugitive EDC emissions were prorated using the EtCl:EDC weight fraction. As noted previously, tnis weight fraction was based upon composition data for process vents. It is not known how equipment leak composition might differ from process vent composition.

The stream characteristics for equipment leaks are default values. An exception to this is that source area was known for some facilities.

The methods of calculation and references for all values are given in the following sections.

G.3.1 Ethyl Chloride Equipment Leak Rates

In the 114 responses used for these calculations, component counts were broken down into categories of EDC weight percent for the emission stream. The six weight percent categories are given in table G.3-1. For four of the weight percent categories, it was assumed that the midpoint of the percent range was the best estimate of the actual percent for all components in that range. For the lowest (<5%) and the highest (>99%) composition streams, the upper bound, being the conservative estimate, was used.

Table G.3-1 Representative Weight Percent

Weight Percent Category (%)	Midpoint or Assigned Value (%)	Mass (Weight) Fraction
<5	5	0.05
5-10	7.5	0.075
11-25	18	0.18
26-75	50.5	0.505
76-99	87.5	0.875
>99	100	1.00

To simplify the necessary calculations, the number of components in each category and the representative weight percent of that category were combined to give a single number of each type of component. This number was a value equivalent to assuming all components were in 100 percent EDC service. In other words, the equipment counts for the six categories were condensed to a single equivalent equipment count. The components of the equivalent equipment count were all assumed to be in use only for EDC.

Figure G.3-1 gives a generalized mathematical expression for the procedure that was used to obtain the total EDC emissions for each of the 11 facilities with equipment counts. The step which is mentioned above, which simplified the calculation by means of the 100 percent EDC equivalent equipment counts, occurs in the separation of the summations.

$$T = \sum_{j=1}^{n} \sum_{i=1}^{6} x(i)\, q(i,j)\, z(j)$$

$$= \sum_{j=1}^{n} z(j) \sum_{i=1}^{6} x(i) q(i,j)$$

j= number of component types (i.e. pumps, valves, etc.)

z(j)= emission factor for total organics, specific for each component type. (kg/hr/source)

i= number of ranges or values for the mass fraction of the chemical of concern, x, of total organics

x(i)= mass fraction of chemical of concern (kg x/kg z)

q(i,j)= number of components of type j which contain mass fraction x(i) of chemical of concern.

T= total emissions of x from process unit (kg/hr)

Figure G.3-1 Summations for process unit emissions of an Organic Species.

The inner summation in figure G.3-1 is what has previously been refered to as the equivalent equipment count. The simplified example below demonstrates how the equations in figure G.3-1 were used.

Example - Obtaining an Equivalent Equipment Count Facility with the following equipment count for EDC:

Table G.3-2 Simplified Version of a 114 Equipment Count weight percent of EDC-

valves	<5%	5-10%	11-25%	26-75%	76-99%	>99%
vapor service	1	0	5	0	0	0
liquid service	0	2	0	0	2	1

From the ranges for weight percent-
$x(1)=.05$, $x(2)=.075$, $x(3)=.18$, $x(4)=.505$, $x(5)=.875$, $x(6)=1.00$

From table G.3-2
$q(1,1)=1$, $q(2,1)=0$, $q(3,1)=5$,. $q(6,1)=0$
$q(1,2)=0$, $q(2,2)=2$,...$q(6,2)=1$

Equivalent 100 percent EDC equipment count-

$$\sum_{i=1}^{6} x(i)q(i,j)$$

for vapor service valves = $.05(1)+.075(0)+.18(5)+0+0+0$
$= 0.95$
for liquid service valves = $.05(0)+.075(2)+0+0.875(2)+1.00(1)$
$= 2.90$

For this example, the following approximations of organic emission factors are used:

valves in vapor service = 0.006 kg/hr/source
valves in liquid service = 0.004 kg/hr/source
That is, $z(1) = 0.006, z(2) = 0.004$

$$\text{Total emissions of EDC} = \sum_{j=1}^{2} z(j) \sum_{i=1}^{6} x(i)q(ij)$$

$$= .006(0.95)+.004(2.90)$$

$$= 0.0173 \text{ kg/hr}$$

The equivalent equipment counts which were obtained for the eleven facilities with 114 responses are given in table G.3-3. The average value for each component, which was obtained from the eleven data sets, is also given in the table.

Using the same methodology as illustrated in the example, the total emissions of EDC were estimated for the facilities given in table G.3-5. The second column in this table shows the estimated emissions of EtCl, these values were obtained by multiplying the EDC estimate by the EtCl:EDC ratio. In order to obtain an annual emission estimate, it was assumed that each facility operates continuously, i.e. 8760 hours per year.

Average values for EDC and EtCl emissions were determined based upon the 114 equipment counts. Although they might have been, these averages were not used for the facilities with unknown equipment counts. EDC fugitive estimates from the EDC project were believed to give a better basis for EtCl emissions than the use of average values would. However, the averages are included in the table for comparison purposes.

Another way to estimate equipment leaks at facilities with out equipment counts would have been to use the model plant approach. The averages could have been compared with values for a model SOCMI facility.[10] (This comparison was made and the average counts fit best with the model B facility). Then the equipment count for the model facility could have been used for the unknown counts.

Again, the EDC fugitive calculations developed for the EDC project, were thought to give the best basis for calculating EtCl equipment leaks. Table G.3-6 lists the EDC estimates and the EtCl estimates which were derived for the seven EDC production facilities without site specific equipment counts.

Table G.3-3 Equivalent (100% EDC) Equipment Counts[a,b]

Company Component	A	B	C	D	E	F	G	H	I	J	K	average ± standard deviation
Pump Seals												
Packed	0	0	0	0	0	0	0.25	0	0	0	0	.023±.075
Mechanical	0.05	9.84	31.0	74.4	56.0	26.5	0.20	14.8	23.0	22.0	22.8	26±22
Double Mechanical	7.35	0	2.94	0.95	0.20	11.5	40.4	0	7.52	4.92	0	6.9±12
Compressors	1.0	0	0.225	0	0.30	5.52	1.11	0	0.51	1.29	0.10	0.91±1.6
Flanges	474	190	4050	6700	2010	1400	1960	790	2580	3060	1180	2200±1900
Valves												
Gas	60.4	4.75	69.0	268	141	175	170	52.7	97.5	452	71.2	140±130
Liquid	100	115	630	2410	332	413	659	231	888	1240	245	660±680
Pressure Relief Devices												
Gas	3.32	7.18	29.0	26.1	29.2	31.0	18.2	8.66	47.9	19.5	3.75	20±14
Liquid	3.06	0	10.9	9.0	0	22.2	2.46	1.52	0	21.0	5.38	6.9±8.1
Sample Connections												
Gas	5.95	0	0	56.5	14.7	0	2.96	0	0.325	0	7.58	8.0±17
Liquid	10.1	8.16	29.0	711	25.6	17	10.5	28.4	12.9	18.5	19.0	81±210
Open Ended Lines												
Gas	0	0	0.225	0	52.7	72.0	17.2	2.88	0	158	8.15	28±49
Liquid	0	0	34.0	0	117	133	0	38.3	0	447	0	70±130

a. All values are rounded to three significant figures except averages and standard deviations which are rounded to two significiant figures.

footnotes for Table G.3-3 (cont.)

b. Original equipment counts were given in the following 114 responses:

114 responses -

1. Letter from JW Chapein, Arco, to J Farmer, OAQPS, EPA, dated March 29, 1984.
2. Letter from S Arnold, Dow Chemical, to J Farmer, OAQPS, EPA dated April 25, 1984.
3. Letter from C McAulliffe, Formosa Plastics Corp., to J Farmer, OAQPS, EPA, dated March 28, 1984
4. Letter from LE Kerr, Olin Corp., to J Farmer, OAQPS, ESA, dated July 23, 1984.
5. Report for Site Visit to Shell Chemical Company, Deer Park, TX, April 2, 1984, from JR Butler, Midwest Research Institute to DA Beck, OAQPS, EPA.
6. Letter form RA Conrad, Conoco Chemicals, to J Farmer, OAQPS, EPA, dated May 15, 1984.
7. Letter from CV Gordon, Vulcan Chemicals, to J Farmer, OAQPS, EPA, dated May 7, 1984.

The component categories in the 114 responses (e.g., five pumps, three valves) were the same as the component categories of the average synthetic organic chemical manufacturing industry (SOCMI) emission factors for equipment leaks. However, the phase and composition of the process streams are unknown.

Table G.3-4 shows the original emission factors[10] and how they were combined with the 114 equipment counts.

Table G.3-4 Average SOCMI Emission Factors and Modifications

Component	Average SOCMI factors[a] (kg/hr/source)	Value used for EDC[b] (kg/hr/source)
Pump Seals:		
light liquid	.0494	.0354
heavy liquid	.0214	"
Compressor Seals	.228	.228
Flanges	.00083	.00083
Valves:		
gas	.0056	.0056
light liquid	.0071	.0037
heavy liquid	.00023	"
Safety Relief Valves-gas	.104	.104
Sampling Connections	.0150	.0150
Open-Ended Lines	.0017	.0017

Table G.3-5 Estimated Equipment Leaks based on 114 Data[a].

Company, Location	estimated EDC equipment leak emissions[b] (kg/hr)	estimated EtCl equipment leak emissions[c] (kg/hr)	annual EtCl equipment leaks[d] (Mg/yr)
U.S. Industrial Chemicals Port Arthur, TX	2.5	1.2	11.
Dow Chemical Freeport, TX	1.8	0.90	7.8
Dow Chemical Oyster Creek, TX	12	5.9	51
Dow Chemical Plaquemine I, LA	34	17	150
Dow Chemical Plaquemine II, LA	9.7	4.7	42
Formosa Plastics Baton Rouge, LA	12	6.1	53
Formosa Plastics Point Comfort, TX	9.1	4.5	39
Olin Lake Charles, LA	3.9	1.9	17
Shell Deer Park, TX	12	6.0	53
Vista Westlake, LA	16	8.0	70
Vulcan Geismar, LA	4.5	2.2	19
Total	118	58.4	508
avg $\pm$ std. dev.	11$\pm$9.0	5.3$\pm$4.4	46$\pm$39

a. All numbers have been rounded to two significant figures.
b. Values based upon 114 responses and average SOCMI factors. See references 2-10 and previous sections of this appecdix.
c. (EDC emissions) x EtCl: EDC weight ratio (0.49:1.0)
d. 8760 hours of annual operation assumed for all facilities

Table G.3-6 Estimated Equipment Leaks Based on EDC Fugitive Emissions[a]

Company Location	estimated EDC equipment leak emissions[b] (Mg/yr)	estimated EtCl equipment leak emissions[c] (Mg/yr)
BF Goodrich Calvert City, KY	75	37
BF Goodrich LaPorte, TX	75	37
Borden Geismar, LA	130	62
Diamond Shamrock Convent, LA	130	62
Diamond Shamrock Pasadena, TX	75	37
Georgia Gulf Plaquemine, LA	170	82
PPG Industries Lake Charles, LA	47	23
Total	702	340

a. All values are rounded to two significant figures.
b. Memorandum from M Putnam, Midwest Research Institute, to Dave Beck OAQPS,EPA. Estimates of Ethylene Dichloride Emissions from Production Facilities and HEM inputs. April 23, 1986.p.5-11
c. (EDC emissions) x E+Cl:EDC weight ratio (0.49:1.0)

G.3.2 EtCl Equipment Leak Stream Characteristies

Most of the stream characteristics for ethyl chloride equipment leaks are standard default values. These default values are: emission release height, 3.0 m; emission velocity, 0.01 m/s; and temperature, 293 K.

Some site specific values for the area were given in the 114 responses. Other values were given in the EDC memorandum. For those facilities for which neither of these values was given, the average of the values derived from the 114 responses was used. Table G.3.7 lists the facilities, the release area, and the reference for the release area.

Table G.3.7 Equipment Leak Release Area

Company, Location	release area (m^2)	reference
U.S. Industrial Chemicals Port Arthur, TX	36,000	114 average[a]
BF Goodrich Calvert City, KY LaPorte, TX	36,000 36,000	114 average[a] 114 average[a]
Bordon Geismar, LA	142,516	EDC memorandum[b]
Diamond Shamrock Convent, LA Pasadena, TX	36,000 142,516	114 average[a] EDC memorandum
Dow Chemical Freeport, TX Oyster Creek, TX Plaquemine I, LA Plaquemine II, LA	36,000 36,000 23,000 126,994	114 average[a] 114 average[a] 114 response[c] EDC memorandum[b]
Formosa Baton Rouge, LA Point Comfort, TX	25,083 1,300,000	EDC memorandum [b] EDC memorandum [b]
Georgia Gulf Plaquemine, LA	36,000	114 average[a]
Olin Lake Charles, LA	930	114 response[d]
PPG Industries Lake Charles, LA	36,000	114 average[a]
Shell Chemical Deer Park, TX	142,516	EDC memorandum[b]
Vista Westlake, LA	36,000	114 average[a]
Vulcan Geismar, LA	5,600	114 response[e]

Footnotes for Table G.3-7

a. The average value from the non confidential 114 responses was used when no other value was available. See table G.2-2.

b. Memorandum from M. Putnam, Midwest Research Institute, to D. Beck, OAQPS, EPA. Estimates of Ethylene Dichloride Emissions from Production Facilities and HEM Inputs. April 23, 1986. p. 5-11.

c. Letter from S. Arnold, Dow Chemical, to J. Farmer, OAQPS, U.S. EPA, dated April 25, 1984.

d. Letter from L.E. Kerr, Olin Corp. to J. Farmer, OAQPS, U.S. EPA dated July 23, 1984.

e. Letter from C.V. Gordon, Vulcan Chemicals to J. Farmer, OAQPS, U.S. EPA dated May 7, 1984.

TABLE G.4-1 DISPERSION MODELING PARAMETERS FOR ETHYL CHLORIDE FROM EDC PRODUCTION*

Company Name/ Plant Location/ Emission Source	North Latitude (deg min s)	West Longitude (deg min s)	Urban (0) Rural (1)	EtCl emission rate (kg/yr)	Stack/ vent height, (meters)	Source area (m^2)	Stack/ vent diameter (m)	emission velocity, (m/s)	emission temp (K)
U.S. Industrial Chemicals	29 51 56	93 59 49	0						
Port Arthur, TX									
process				22	15.2	---	0.46	0.23	298
equipment leaks				10,700	3.0	36,000	----	0.01	293
BF Goodrich	37 02 50	88 19 20	1						
Calvert City, KY									
process				1,040	15.2	----	0.58	7.9	303
process				1,040	15.2	----	0.58	7.9	303
equipment leaks				36,900	3.0	36,000		0.01	293
BF Goodrich	29 46 00	95 05 00	0						
LaPorte, TX									
process				585	15.2	----	0.58	7.9	303
process				585	15.2	----	0.58	7.9	303
equipment leaks				36,900	3.0	36,000	----	0.01	293
Borden	30 12 20	91 01 08	0						
Geismar, LA									
process				21,000	31.1	----	0.81	7.9	339
equipment leaks				62,400	3.0	142,516	----	0.01	293
Diamond Shamrock	30 03 44	90 49 55	0						
Convent, LA									
process				22	15.2	----	0.58	7.9	303
equipment leaks				62,400	3.0	36,000	----	0.01	293
Diamond Shamrock	29 43 00	95 07 00	0						
Pasadena, TX									
process				21,000	31.1	----	0.81	7.9	339
equipment leaks				36,900	3.0	142,516	----	0.01	293

TABLE G.4-1 DISPERSION MODELING PARAMETERS FOR ETHYL CHLORIDE FROM EDC PRODUCTION* (cont.)

Company Name/ Plant Location/ Emission Source	North Latitude (deg min s)	West Longitude (deg min s)	Urban (0) Rural (1)	EtCl emission rate (kg/yr)	Stack/ vent height, (meters)	Source area (m^2)	Stack/ vent diameter (m)	emission velocity, (m/s)	emission temp (K)
Dow Chemical	28 57 39	95 19 24	0						
Freeport, TX									
process				22	7.3	---	0.05	0.86	303
equipment leaks				7,850	3.0	36,000	----	0.01	293
Dow Chemical	28 58 00	95 21 00	1						
Oyster Creek, TX									
process				15,100	7.0	---	0.67	0.13	313
process				15,100	18.3	---	0.76	0.14	313
process				15,100	17.2	---	0.71	1.7	313
equipment leaks				51,400	3.0	36,000	----	0.01	293
Dow Chemical	30 19 46	91 14 21	0						
Plaquemine I, LA									
process				430	15.2	---	0.76	0.15	268
process				431	15.2	---	0.76	0.76	268
equipment leaks				145,000	3.0	23,000	----	0.01	293
Dow Chemical	30 19 46	91 14 21	0						
Plaquemine II, LA									
process				1985	15.2	---	0.61	7.9	323
process				1985	15.2	---	0.61	7.9	268
equipment leaks				41,500	3.0	126,994	----	0.01	293
Formosa	30 30 00	91 11 00	0						
Baton Rouge, LA									
process				18,600	22.9	---	0.61	7.9	310
equipment leaks				53,300	3.0	25,083	----	0.01	293

TABLE G.4-1 DISPERSION MODELING PARAMETERS FOR ETHYL CHLORIDE FROM EDC PRODUCTION* (CONT.)

Company Name/ Plant Location/ Emission Source	North Latitude (deg min s)	West Longitude (deg min s)	Urban (0) Rural (1)	EtC2 emission rate (kg/yr)	Stack/ vent height, (meters)	Source area (m^2)	Stack/ vent diameter (m)	emission velocity, (m/s)	emission temp (K)
Formosa	28 41 04	96 32 12	1						
Point Comfort, TX									
process				198	35.7	---	0.61	11	339
process				199	35.7	---	0.61	11	339
equipment leaks				39,000	3.0	1,300,000	----	0.01	293
Georgia Gulf	30 16 30	91 10 30	0						
Plaquemine, LA									
process				5,950	18.5	---	0.58	7.9	303
process				5,950	18.5	---	0.58	7.9	303
equipment leaks				81,500	3.0	36,000	----	0.01	293
Olin Corporation	30 14 00	93 16 00	0						
Lake Charles, LA									
process				22	18.5	---	0.58	7.9	303
equipment leaks				16,700	3.0	930	----	0.01	293
PPG Industries	30 13 27	93 16 59	0						
Lake Charles, LA									
process				3,680	18.5	---	0.58	7.9	303
process				3,680	18.5	---	0.58	7.9	303
equipment leaks				23,000	3.0	36,000	----	0.01	293
Shell Chemical	29 43 04	95 07 53	0						
Deer Park, TX									
process				54	25.9	---	0.75	7.9	339
process				54	25.9	---	0.75	7.9	339
equipment leaks				53,000	3.0	142,516	----	0.01	293

TABLE 5.1-4 Ethyl Chloride Emissions from EDC Production (cont.)

Company Name/ Plant Location/ Emission Source	North Latitude (deg min s)	West Longitude (deg min s)	EtCl emission rate (kg/yr)	Stack/ vent height, (meters)	Source area (m^2)	Stack/ vent diameter (m)	emission velocity, (m/s)	emission temp (K)
Vista	30 15 04	93 17 00						
Westlake, LA								
process			10	44.2	---	0.90	7.9	316
process			11	44.2	---	0.90	7.9	316
equipment lea			70,400	3.0	36,000	----	0.01	293
Vulcan Chemicals	30 11 30	90 58 27						
Geismar, LA								
process			25	15.2	---	.15	7.9	323
process			26	15.2	---	.15	7.9	323
equipment leaks			19,200	3.0	5,600	----	0.01	293

*Latitudes, longitudes, and urban/rural designations are from Table 1. In: Dispersion Modeling Parameters for Ethylene Dichloride - EDC Case 1 in Memorandum from Marjorie Putnam, Midwest Research Institute, to Dave Beck, ESD, U.S. EPA, April 23, 1986. Estimates of Ethylene Dichloride Emissions from Production Facilities and HEM Inputs. References and other values are specified in table G.4-2 - References for Ethyl Chloride Dispersion Modeling Parameters.

TABLE G.4-2 REFERENCES FOR ETHYL CHLORIDE DISPERSION MODELING PARAMETERS

Company/ Plant Location	Process Rate	Emissions Stream Characteristics	Equipment Leaks Rate	Stream Characteristics	Exceptions
U.S. Industrial Chemicals					
Port Arthur, TX	C	B1	A1	D	area-Bavg
BF Goodrich					
Calvert City, KY	C	Bavg	C	D	area-Bavg, p.vel-D
LaPorte, TX	C	Bavg	C	D	area-Bavg
Borden					
Geismar, LA	C	D	C	D	
Diamond Shamrock					
Convent, LA	C	Bavg	C	D	area-Bavg
Pasadena, TX	C	D	C	D	area-Bavg
Dow Chemical					
Freeport, TX	C	B2	A2	D	area-Bavg
Oyster Creek, TX	C	B2	A2	D	area-Bavg
Plaquemine I, LA	C	B2	A2	D	area-Bavg
Plaquemine II, L	C	D	A2	D	
Formosa					
Baton Rouge, LA	C	D	A3	D	p.temp-B3
Point Comfort, T	C	D	A3	D	
Georgia Gulf					
Plaquemine, LA	C	Bavg	C	D	area-Bavg
Olin					
Lake Charles, LA	C	Bavg	A4	D	area-Bavg
PPG Industries					
Lake Charles, LA	C	Bavg	C	D	area-Bavg
Shell Chemical					
Deer Park, TX	C	B5	A5	D	
Vista					
Westlake, LA	C	B6	A6	D	area-Bavg
Vulcan Chemicals					
Geismar, LA	C	B7	A7	D	area-B7, p.vel-D

Table G.4-2 (cont.)

Footnotes for table G.4-2 Details of calulations are given in previous sections of Appendix G.

A - Equipment leak emission rates for ethyl chloride (EtCl) were based upon 1) site specific equipment counts for ethylene dichloride (EDC) provided in responses to 114 questionnaires, 2) average synthetic organic chemical manufacturing industry (SOCMI) unit emission factors (U.S. Environmental Protection Agency, Fugitive Emission Sources of Organic Compounds - Additional information on Emissions, Emission Reductions, and Costs, EPA 450/3-82-010, Research Triangle Park, NC, April 1982. p. 2-70), and 3) a ratio of EtCl emissions to EDC emissions of 0.49:1 which was derived from data in: Report 1 Ethylene Dichloride, in U.S. E.P.A., Organic Chemical Manufacturing, Volume 8: Selected Processes, EPA-450/3-80-028c, Research Triangle Park, NC. December 1980. pF-4,5.

Original references for the specific sites are as follows:

1. Letter from J.W. Chupein, Arco, to J. Farmer, Office of Air Quality Planning and Standards, U.S. E.P.A., dated March 29, 1984.

2. Letter from S. Arnold, Dow Chemic . to J. Farmer, OAQPS, U.S. E.P.A. dated April 25, 1984.

3. Letter from C. McAulliffe, Formosa Plastics Corp., to J. Farmer, OAQPS, U.S. E.P.A. dated March 25, 1984.

4. Letter from L.E. Kerr, Olin Corp. to J. Farmer, OAQPS, U.S. E.P.A. dated July 23, 1984.

5. Report for Site Visit to Shell Chemical Company, Deer Park, TX on April 2, 1984 from J.R. Butler, MRI, to D.A. Beck, OAQPS, U.S. E.P.A.

6. Letter from R.A. Conrad, Conoco Chemicals Company to J. Farmer, OAQPS, U.S. E.P.A. dated May 15, 1984.

7. Letter from C.V. Gordon, Vulcan Chemicals to J. Farmer, OAQPS, U.S. E.P.A. dated May 7, 1984.

B - Site specific stream characteristics (i.e. all or part of the following: stack height, source area, stack diameter, flow rate (acfm), and emission temperature) were available in responses to 114 questionnaires. The number for a specific reference indicates the response letter as numbered above in footnote A.

Bavg - The data available from the 114 questionnaires were compiled to obtain average values for certain stream characteristics. The averages which were used in the table, are listed below. The standard deviation for each average is also listed to indicate the variation in the available data.

number of process vents = 2.2 ± 1.9
source area (m^2) = 36,400 ± 51,800
stack height (m) = 18.5 ± 10.2
stack diameter (m) = 0.58 ± 0.27
process vent emission temperature (°C) = 29.6 ± 24.2

C - The emission rates for all process vents and the equipment leaks for facilities which did not receive 114 questionnaires were calculated based upon 1) ethylene dichloride emission rates as given in Memorandum from M Putnam, Midwest Research Institute, to D. Beck, OAQPS, E.P.A. Estimates of Ethylene Dichloride Emissions from Production Facilities and HEM Inputs. April 23, 1986. p. 5-11. and 2) the E+Cl:EDC ratio (see reference in A). The EDC process emissions were calculated and then multiplied by the Etcl:EDC ratio. The total EtCl process emissions were then divided by the number of process vents.

$$\text{Total EDC (kg/yr)} \times \frac{\text{EtCl (kg)}}{\text{EDC (kg)}} = \text{EtCl (kg/yr)}$$

D - Default values and stream characteristics from EDC production analysis. The values, as given in the EDC memorandum (referenced in C above) were:

	Stack/ vent height (m)	Stack/ vent diameter (m)	Emission velocity (m/s)	Temperature (K)
equipment leaks	3.0	----	0.01	293

When data necessary to determine velocity of the process stream were not available, the value 7.9 m/s was used. This value was also from the EDC memorandum.

Appendix G References

1. U.S. Environmental Protection Agency, Report 1: Ethylene Dichloride In: Organic Chemical Manufacturing, Volume 8. Selected Processes, EPA-450/3-80-028c. December 1980. p. F-4,5.

2. Letter from J.W. Chupein, Arco, to J. Farmer, Office of Air Quality Planning and Standards, U.S. EPA, dated March 29, 1984.

3. Letter from S. Arnold, Dow Chemical, to J. Farmer, OAQPS, U.S. EPA dated April 25, 1984.

4. Letter from C. McAulliffe, Formosa Plastics Corp., to J. Farmer, OAQPS, U.S. EPA dated March 25, 1984.

5. Letter from L.E. Kerr, Olin Corp. to J. Farmer, OAQPS, U.S. EPA dated July 23, 1984.

6. Report for Site Visit to Shell Chemical Company, Deer Park, TX on April 2, 1984 from J.R. Butler, MRI, to D.A. Beck, OAQPS, U.S. EPA.

7. Letter from R.A. Conrad, Conoco Chemicals Company to J. Farmer, OAQPS, U.S. EPA dated May 7, 1984.

8. Letter from C.V. Gordon, Vulcan Chemicals to J. Farmer, OAQPS, U.S. EPA dated May 7, 1984.

9. Memorandum from M. Putnam, Midwest Research Institute, to D. Beck, OAQPS, U.S. EPA. Estimates of Ethylene Dichloride Emissions from Production Facilities and HEM Inputs. April 23, 1986. p. 5-11.

10. U.S. Environmental Protection Agency, Fugitive Emission Sources of Organic Compounds - Additional Information on Emissions, Emission Reductions, and Costs, EPA 450/3-82-010, Research Triangle Park, NC, April 1982. p. 1-6, 2-70.

APPENDIX H. HUMAN EXPOSURE MODEL (HEM) INPUTS

The human exposure model (HEM) is a screening model which is used in the risk assessment process. The model combines emission estimates, health assessment, and census data to indicate the relative risk to the public from emissions of a chemical.

The input parameters necessary for the dispersion model are listed in Tables H.2-1 through H.2-5. Information on the bases and estimation of these values is given in the main text and the other appendices of this document.

H.1. Default Parameters

Process specific data for emissions are rarely available. Because of this, default input parameters frequently must be used for dispersion modeling. Some of these default parameters have to do with the location of point sources. If the specific latitude and longitude of a process facility are not available, the latitude and longitude of the city in the facility's address are used. Unless other information is available, facilities are assumed to be located in rural, rather than urban, areas. The rural designation means that a less turbulent air flow pattern will be used in the dispersion model.

Frequently used default parameters for equipment leaks are given in Table H.1-1.

Table H.1-1 - Equipment Leak Default Parameters

Stack/vent height (meters)	Emission velocity (M/s)	Emission temp. (K)
3	0.01	298

Because process emission data are rarely available, it is frequently necessary to make assumptions or use default values for those emission parameters also. An ambient temperature, in the range of 293-300K is frequently assumed unless other information is available.

One of the necessary parameters is the emission steam velocity. The velocity used for ethyl chloride production is given in Appendix C. Unit conversions for a reasonable range of process emission velocities are given below.

Process Velocity Emissions:

Basis: Reasonable velocity range = 2,500 - 3,000 fpm from: American Conference of Governmental Industrial Hygienists, Industrial Ventilation: A Manual of Recommended Practice, 14th Ed. ACGIH. Lansing Michigan. 1977. p.6-23.

$$\frac{2{,}500 \text{ ft} \times 1 \text{ min} \times 1 \text{ meter}}{\text{min} \quad 60 \text{ sec} \quad 3{,}281 \text{ ft}} = 12.7 \text{ meter/s}$$

$$\frac{3{,}000 \text{ ft} \times 1 \text{ min} \times 1 \text{ meter}}{\text{min} \quad 60 \text{ sec} \quad 3.281 \text{ ft}} = 15.2 \text{ meter/s}$$

H.2. HEM Input Tables

The values in these tables are estimates based upon readily availble information. IThey should only be used while keeping in mind the uncertainties and limitations associated with the calculation of these estimates. Insight into these limitations may be gained by familiarity with the industries, the processes, and the various methods of estimation which were used to obtain the values.

TABLE H.2-1 DISPERSION MODELING PARAMETERS FOR ETHYL CHLORIDE FROM ETHYL CHLORIDE PRODUCTION

Company Name/ Plant Location/ Emission Source	North Latitude (deg min s)	West Longitude (deg min s)	Urban (0) Rural (1)	EtCl emission rate (kg/yr)	Stack/ vent height, (meters)	Source area (m^2)	Stack/ vent diameter (m)	emission velocity, (m/s)	emission temp (K)
Dow Chemical USA	28 57 40	95 19 24	1						
Freeport, TX									
process				2,180	24.4	---	.09	13	300
process				2,180	24.4	---		13	300
equipment leaks				29.600	3	---	---	0.01	293
E.I. du Pont de Nemours & Co. Inc.	39 41 00	75 29 40	1						
Deepwater, NJ									
process				21,800	24.4	---	.09	13	300
process				21,800	24.4	---	.09	13	300
equipment leaks				29,600	3	---	---	0.01	300
Ethyl Corporation	29 44 26	95 10 09	1						
Pasadena, TX									
process				34,800	24.4	---	.09	13	300
process				34,800	24.4	---	.09	13	300
equipment leaks				29,600	3.0	---	---	0.01	300
PPG Industries	30 13 17	93 16 59	1						
Lake Charles, LA									
process				27,200	24.4	---	.09	13	300
process				27,200	24.4	---	.09	13	300
equipment leaks				29,600	3.0	---	---	0.01	300

TABLE H.2-2 DISPERSION MODELING PARAMETERS FOR ETHYL CHLORIDE FROM TEL PRODUCTION

Company Name/ Plant Location/ Emission Source	North Latitude (deg min s)	West Longitude (deg min s)	Urban (0) Rural (1)	EtCl emission rate (kg/yr)	Stack/ vent height, (meters)	Source area (m^2)	Stack/ vent diameter (m)	emission velocity, (m/s)	emission temp (K)
E.I. du pont de nemours & Co. Inc. Deepwater, NJ	39 41 24	75 30 28	1						
process				54	16	---	0.40	9.7	294
process				3,100	9	---	.003	1	294
process				211,000	38		.46	0.28	294
process				72,000	40		.40	8.7	294
process				73	7.6		.24	5.3	294
process				6,100	49		.43	3.6	294
process				27	26		.9	13	294
process				82	27		1.1	13	294
process				27	38		.06	0.18	294
process				45	38		.030	2.8	294
process				140	27		1.1	13	294
process				140	21		.30	14	294
process				27	38		.61	0.65	294
process				27	38		.61	0.65	294
process				27	38		.61	0.65	294
process				27	38		.61	0.65	294
process				18	9		.24	6.2	294
process				2,000	7.6		.03	8.5	294
process				2,000	7.6		.03	8.5	294
process				2,000	7.6		.03	8.5	294
process				2,000	7.6		.03	8.5	294
process				2,000	7.6		.03	8.5	294
process				2,000	11		.03	8.5	294
process				2,000	11		.03	8.5	294
process				2,000	11		.03	8.5	294
process				29,600	3	3,142,000	---	.01	298
equipment leaks									

TABLE H.2-3 DISPERSION MODELING PARAMETERS FOR ETHYL CHLORIDE FROM EC AND EHEC PRODUCTION

Company Name/ Plant Location/ Emission Source	North Latitude (deg min s)	West Longitude (deg min s)	Urban (0) Rural (1)	EtCl emission rate (kg/yr)	Stack/ vent height, (meters)	Source area (m^2)	Stack/ vent diameter (m)	emission velocity, (m/s)	emission temp (K)
Dow Chemical Co. Midland, MI	43 37 10	84 13 90	1						
equipment leaks				29,600	3	---	---	0.01	293
Hercules, Inc. Hopewell, VA	37 18 20	77 17 10	1						
equipment leaks				29,600	3	---	---	0.01	293

TABLE H.2-4 DISPERSION MODELING PARAMETERS FOR ETHYL CHLORIDE FROM POLYSTYRENE FOAM BLOWING

Company Name/ Plant Location/ Emission Source	North Latitude (deg min s)	West Longitude (deg min s)	Urban (0) Rural (1)	EtCl emission rate (kg/yr)	Stack/ vent height, (meters)	Source area (m^2)	Stack/ vent diameter (m)	emission velocity, (m/s)	emission temp (K)
Dow Chemical USA	41 26 29	72 04 58	1						
Allyn's Point/									
Gales Ferry, CT									
process				50	10	---	1.1	14	300
equipment leaks				20	3	---	---	0.01	300
storage				84	3	21,000	---	0.01	300
Dow Chemical USA	34 46 06	84 57 42	1						
Dalton, GA									
process				70	10	---	1.1	14	300
equipment leaks				20	3	---	---	0.01	300
storage				120	3	21,000	---	0.01	300
Dow Chemical USA	38 31 00	82 40 00	1						
Ironton, OH									
process				70	10	---	1.1	14	300
equipment leaks				20	3	---	---	0.01	300
storage				120	3	21,000	---	0.01	300
Dow Chemical USA	41 31 36	88 04 48	1						
Joliet, IL									
process				70	10	---	1.1	14	300
equipment leaks				20	3	---	---	0.01	300
storage				120	3	21,000	---	0.01	300
Dow Chemical USA	39 10 06	94 36 12	1						
Pevely/									
Riverside, MO									
process				110	10	---	1.1	14	300
equipment leaks				20	3	---	---	0.01	300
storage				180	3	21,000	---	0.01	300
Dow Chemical USA	33 51 02	118 19 49	1						
Torrrance, CA									
process				20	10	---	1.1	14	300
equipment leaks				20	3	---	---	0.01	300
storage				36	3	21,000	---	0.01	300

TABLE H.2-5 DISPERSION MODELING PARAMETERS FOR ETHYL CHLORIDE FROM EDC PRODUCTION

Company Name/ Plant Location/ Emission Source	North Latitude (deg min s)	West Longitude (deg min s)	Urban (0) Rural (1)	EtCl emission rate (kg/yr)	Stack/ vent height, (meters)	Source area (m^2)	Stack/ vent diameter (m)	emission velocity, (m/s)	emission temp (K)
U.S. Industrial Chemicals	29 51 56	93 59 49	0						
Port Arthur, TX									
process				22	15.2	---	0.46	0.23	298
equipment leaks				10,700	3.0	36,000	----	0.01	293
BF Goodrich	37 02 50	88 19 20	1						
Calvert City, KY									
process				1,040	15.2	----	0.58	7.9	303
process				1,040	15.2	----	0.58	7.9	303
equipment leaks				36,900	3.0	36,000		0.01	293
BF Goodrich	29 46 00	95 05 00	0						
LaPorte, TX									
process				585	15.2	----	0.58	7.9	303
process				585	15.2	----	0.58	7.9	303
equipment leaks				36,900	3.0	36,000	----	0.01	293
Borden	30 12 20	91 01 08	0						
Geismar, LA									
process				21,000	31.1	----	0.81	7.9	339
equipment leaks				62,400	3.0	142,516	----	0.01	293
Diamond Shamrock	30 03 44	90 49 55	0						
Convent, LA									
process				22	15.2	----	0.58	7.9	303
equipment leaks				62,400	3.0	36,000	----	0.01	293
Diamond Shamrock	29 43 00	95 07 00	0						
Pasadena, TX									
process				21,000	31.1	----	0.81	7.9	339
equipment leaks				36,900	3.0	142,516	----	0.01	293

TABLE H.2-5 DISPERSION MODELING PARAMETERS FOR ETHYL CHLORIDE FROM EDC PRODUCTION (cont.)

Company Name/ Plant Location/ Emission Source	North Latitude (deg min s)	West Longitude (deg min s)	Urban (0) Rural (1)	EtC2 emission rate (kg/yr)	Stack/ vent height, (meters)	Source area (m^2)	Stack/ vent diameter (m)	emission velocity, (m/s)	emission temp (K)
Dow Chemical	28 57 39	95 19 24	0						
Freeport, TX									
process				22	7.3	---	0.05	0.86	303
equipment leaks				7,850	3.0	36,000	----	0.01	293
Dow Chemical	28 58 00	95 21 00	1						
Oyster Creek, TX									
process				15,100	7.0	---	0.67	0.13	313
process				15,100	18.3	---	0.76	0.14	313
process				15,100	17.2	---	0.71	1.7	313
equipment leaks				51,400	3.0	36,000	----	0.01	293
Dow Chemical	30 19 46	91 14 21	0						
Plaquemine I, LA									
process				430	15.2	---	0.76	0.15	268
process				431	15.2	---	0.76	0.76	268
equipment leaks				145,000	3.0	23,000	----	0.01	293
Dow Chemical	30 19 46	91 14 21	0						
Plaquemine II, LA									
process				1985	15.2	---	0.61	7.9	323
process				1985	15.2	---	0.61	7.9	268
equipment leaks				41,500	3.0	126,994	----	0.01	293
Formosa	30 30 00	91 11 00	0						
Baton Rouge, LA									
process				18,600	22.9	---	0.61	7.9	310
equipment leaks				53,300	3.0	25,083	----	0.01	293

TABLE H.2-5 DISPERSION MODELING PARAMETERS FOR ETHYL CHLORIDE FROM EDC PRODUCTION (cont.)

Company Name/ Plant Location/ Emission Source	North Latitude (deg min s)	West Longitude (deg min s)	Urban (0) Rural (1)	EtC2 emission rate (kg/yr)	Stack/ vent height, (meters)	Source area (m^2)	Stack/ vent diameter (m)	emission velocity, (m/s)	emission temp (K)
Formosa	28 41 04	96 32 12	1						
Point Comfort, TX									
process				198	35.7	---	0.61	11	339
process				199	35.7	---	0.61	11	339
equipment leaks				39,000	3.0	1,300,000	----	0.01	293
Georgia Gulf	30 16 30	91 10 30	0						
Plaquemine, LA									
process				5,950	18.5	---	0.58	7.9	303
process				5,950	18.5	---	0.58	7.9	303
equipment leaks				81,500	3.0	36,000	----	0.01	293
Olin Corporation	30 14 00	93 16 00	0						
Lake Charles, LA									
process				22	18.5	---	0.58	7.9	303
equipment leaks				16,700	3.0	930	----	0.01	293
PPG Industries	30 13 27	93 16 59	0						
Lake Charles, LA									
process				3,680	18.5	---	0.58	7.9	303
process				3,680	18.5	---	0.58	7.9	303
equipment leaks				23,000	3.0	36,000	----	0.01	293
Shell Chemical	29 43 04	95 07 53	0						
Deer Park, TX									
process				54	25.9	---	0.75	7.9	339
process				54	25.9	---	0.75	7.9	339
equipment leaks				53,000	3.0	142,516	----	0.01	293

TABLE H.2-5 DISPERSION MODELING PARAMETERS FOR ETHYL CHLORIDE FROM EDC Production (cont.)

Company Name/ Plant Location/ Emission Source	North Latitude (deg min s)	West Longitude (deg min s)	EtCl emission rate (kg/yr)	Stack/ vent height, (meters)	Source area (m^2)	Stack/ vent diameter (m)	emission velocity, (m/s)	emission temp (K)
Vista	30 15 04	93 17 00						
Westlake, LA								
process			10	44.2	---	0.90	7.9	316
process			11	44.2	---	0.90	7.9	316
equipment lea			70,400	3.0	36,000	----	0.01	293
Vulcan Chemicals	30 11 30	90 58 27						
Geismar, LA								
process			25	15.2	---	.15	7.9	323
process			26	15.2	---	.15	7.9	323
equipment leaks			19,200	3.0	5,600	----	0.01	293